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THE FORESTER

THE FORESTER

A PRACTICAL TREATISE

ON THE PLANTING AND TENDING OF FOREST TREES AND THE GENERAL MANAGEMENT OF WOODLAND ESTATES

BY

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SIXTH EDITION, ENLARGED

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'BRITISH FOREST TREES AND THEIR SYLVICULTURAL CHARACTERISTICS AND TREATMENT,'
'STUDIES IN FORESTRY,' 'PROTECTION OF WOODLANDS,' ETC.

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THE FORESTER.

CHAPTER VIII.

THE ENCLOSURE OF PLANTATIONS, HEDGING, FENCING, &c.

Utility of Enclosure.—In Britain it is the custom that every piece of land laid out for a plantation should be fenced in some way or other previous to its being planted. A fence not only prevents the inroads of sheep and cattle, but at the same time tends very much to shelter the edge of the wood against the drying and exhausting effect of winds. Any proprietor or forester, upon looking through his several plantations, will observe that in all young plantations the most rapid growing and at the same time the most healthy trees in it, are to be found immediately within the shelter of the outer fence; whilst, on the other hand, in all older plantations, the best grown, and at the same time the most healthy trees, are to be found in the centre of the wood, or at least a considerable distance back from the fence.

The reasons why the best wood is found in the inner parts of old plantations, while the most rapid growth of the young trees is to be found behind the boundary fence, are not far to seek. During the first eight or ten years of the growth of any young plantation, the boundary fence is the only shelter which the young trees have. It is quite evident that those trees which grow immediately behind the fence will receive most of the benefit of its shelter; consequently, from the circumstance of their receiving more shelter than their neighbours farther off, they can grow more rapidly, until such time as their tops begin to rise above the level of the fence, when they are considerably checked by the cold winds. At this stage they assume a tendency to grow

thick and bushy rather than to advance in height. But immediately upon their becoming rough-crowned, they begin to shelter all the individual trees lying behind them to the inside, which thus begin to have an advantage over their neighbours outside; for the trees upon the outside had shelter only so long as they were below the level of the top of the fence, whereas those inside have now a shelter which every year increases in height as well as in thickness.

In a previous chapter it has already been shown that the cost of enclosing land usually amounts to very considerably more than the costs of soil-preparation and planting, even when the plants have to be purchased from nurseries,—in place of being reared on the estate, as they ought to be wherever planting operations are extensive.

Now this **unproductive expenditure** must if possible be reduced or eliminated, if **Sylviculture** is to be practised, *i.e.*, if Forestry is to be carried on upon a sound financial principle. The vast forests of continental Europe are not fenced in, except in the case of large deer-parks; and there is no reason from a sylvicultural point of view why enclosure should take place. The sole object of the fences round deer-parks is not to keep cattle out, but to keep deer in; and the shelter afforded to the edge of the wood by a dyke can be provided much more cheaply, and just as effectively, by planting suitable species (Spruces, Silver Firs, Beech) thickly along the edge of the wood, and allowing them to grow up with as dense an outer covering of foliage as these thickly foliaged species are capable of producing. This can be stimulated, when necessary, by lopping off the tops, in order to induce greater density of branchlets, twigs, and foliage.

So far as regards the straying of cattle into woods, in all countries where **Forestry** means **Sylviculture**,—and not merely **Arboriculture**, as is generally the case in Britain,—the Forest Laws hold owners of cattle responsible for the trespass committed by their herds and flocks.

But circumstances in Britain are different, and under Scots Law one proprietor can force his neighbour to incur expenditure on enclosure. The existing law on this point is set forth in the following extract from Bell's *Dictionary and Digest of the Law of Scotland*, 1890, p. 522:—

"The Act 1661, c. 41, ratified by 1685, c. 39, enables a proprietor to force a conterminous proprietor to concur with him in mutually enclosing their property. And, accordingly, the conterminous heritors must, under this statute, mutually bear the expense of making a march-dyke or proper fence. . . . And in the same manner, fences once made may be kept in repair at the mutual expense of the parties, or, when no longer reparable, may be reconstructed.

"Where the march is a rivulet, which is not a sufficient fence, a proper fence may be built upon the spot, if it be practicable. The fence may run along one side of the stream, but if it be desired, the stream ought to run a space within the fence and a space without, that both parties may have the benefit of watering."

That advantages are derived in Britain from enclosure is an undoubted fact. But what the editor wishes to draw attention to, is that a large unproductive expenditure is incompatible with the principles of profitable Sylviculture; and that the more extensive the woodlands are, the necessity for enclosure becomes proportionately less.

During the early years of the growth of plantations, hares, rabbits,

sheep, and cattle may do a great amount of damage; and where ground game is abundant, there exists no practical possibility of raising young woodland crops except by fencing them carefully and expensively with wire-netting. But the more extensive the areas forming compact woodlands, the less would be the danger from these causes.

In the great forests throughout Germany, where there is often a good stock of large game, with hares, &c., there is seldom any necessity for fencing in anything but the temporary and permanent nurseries throughout the woods.

Upon many estates sheep and cattle may sometimes be found grazing in deciduous plantations not above twenty-five years old, and this is allowed under the impression that the rent received for the grazing outweighs any benefit derivable from preserving the trees by fences. This, however, is a practice very injurious to the welfare of any young plantation; for heavy cattle, when allowed to graze in a plantation of small extent, are always inclined to seek their shade during the warmer part of the day, and to commence gnawing the smooth bark of young trees, as well as the shoots of the tender branches where they can reach up to them. Out of consideration for the welfare of the woodlands, therefore, cattle of any description should never be allowed to have access into a plantation, unless the trees in it are considerably advanced, when the bark of most forest-trees becomes hard and covered with rough scaly protuberances, which resist the action of either the greasiness of sheep or the teeth of cattle. But when plantations have passed through the thicket and the pole-forest stages of growth, and may be regarded as young tree-forest, then the woods may well be opened for grazing, as neither sheep nor cattle are after that at all likely to do damage. In some cases, especially in Larch and Pine woods that are beginning to interrupt their canopy, but which are not yet underplanted, grazing may even be very advantageous in keeping down growth of grass and treading the soil. A *résumé* of the views of German Sylviculturists regarding this matter will be found in the editor's translation of Kauschinger-Fürst's *Protection of Woodlands*, 1893, pp. 69, 83.

Fencing.—There is no fence more generally in use in the cultivated districts of Britain than the Thorn, Quick, or Hawthorn hedge (*Cratægus Oxyacantha*); and considering its permanent nature as a fence upon good land, it is certainly the best adapted for most purposes where a neatness in appearance is desirable. The hedge is very greatly improved by planting Beech or Hornbeam to the extent of one-third among the Thorns; and this is more particularly the case upon high situations with a light soil. There the Thorns are very apt to die early; but when mixed with Beech, which thrives well in a light soil, the fence is much improved both in health and appear-

ance. The soil upon which the Thorn thrives best as a hedge-fence, and in which it is most likely to live to a great age, is a heavy loam resting upon a dry subsoil. In all light soils, such as moss, sand, or gravel, Thorns are very apt to die suddenly; and therefore on land of these characters, Beech, and not Thorn, should always be planted as hedges.

In Macdonald's edition of Stephens's *Book of the Farm*, 1893, Div. V., p. 219, the following passage occurs:—

"It is not unusual to see Beech mixed with Thorn as a hedge; the mixture makes a pleasant-looking hedge; but Beech itself is not a terror to live stock in fields. The Sweet-briar (*Rosa canina*), too, is frequently mixed with the Thorn, and no doubt imparts a delightful perfume to the air after a shower in summer; but it soon overcomes the Thorns near it. The Crab-apple (*Pyrus malus*) also displaces Thorns in hedges. We have only to view the hedges in the southern counties of England to be convinced of the noxious effects of intermixing other plants with the Thorn.

"**Thorn Hedges around Plantations.**—Where Thorns fence plantations, they should be planted at a distance of at least 12 ft. from the nearest tree."

But a distance of 12 ft. clear all round a plantation, or even all round the whole of the woods on any estate, even supposing all the plantations to form a continuous block, would be a waste of land perfectly incompatible with rational Sylviculture. And when the costs of fencing come to be added, and calculated at compound interest, the difference between Arboriculture and Sylviculture becomes still more evident.

Many recommend the practice of manuring poor light soils, for the reception of Thorn plants, in the forming of a hedge-fence; but this is neither necessary, nor usually desirable. Hedges planted with manure in a naturally light poor soil and upon a high situation, certainly grow more freely for the first two or three years after planting. But as soon as the manure becomes exhausted, the plants are inclined to fall into a sickly state; and in the course of five years from the time of planting, such a hedge is often much inferior to others planted out without manure upon the same soil and situation.

On cold, sluggish soils the admixture of a little compost earth with the soil no doubt tends to enable the plants to establish themselves more readily in their new abode; but on light, active soils, easily warmed and stimulated, this is unnecessary. And in any case the amount of compost should not be so great as to accustom the plants to absorb and utilise large supplies of nutrients, which they cannot easily acquire later from the poorer soil alone.

The best manure for Thorns in a light soil is a good dressing of clay or heavy loam, if it can possibly be had; and if that cannot be got, Beech or Hornbeam may be used instead on the natural soil, as

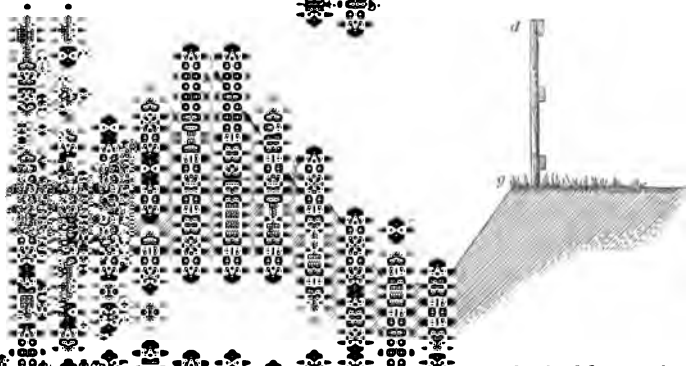
[illegible] tention be paid to keeping [illegible] trimming in autumn or [illegible]

[illegible] Hawthorn is a plant better [illegible] this country than Beech, [illegible] such land it should be [illegible] ere whatever. This may [illegible] from a light loam to a [illegible] lighter than the former. [illegible] loam, a mixture of Beech [illegible] sandy or gravelly, Beech [illegible]

[illegible] here is much greater variety [illegible] Ireland dry-stone dykes and [illegible] In Scotland, Hawthorn [illegible] ricts; but in the Highlands [illegible] se no shelter can be derived [illegible] Blackthorn, Beech, Hornbeam, [illegible] tle, Dogwood, Spindlewood, [illegible]

[illegible] hedges, two methods are [illegible] damp or dry. The one [illegible] e brow of an open ditch, [illegible] keeping the roots of the [illegible] off water from the field or [illegible] method is that of planting [illegible] hout any ditch whatever. [illegible] cording to circumstances.

[illegible]



[illegible] more desirable, as it is the [illegible] It also takes up much [illegible] rendered dry it thrives

Fig. 125 is a section of a hedge planted upon the brow of a ditch, and exhibiting the method of planting, which will be easily understood.

Autumn is the proper time for undertaking hedging operations. In planting a hedge of the description shown in the above figure, the operator first stretches his line along the run of the ground where the hedge is to be planted, and which it is understood has been previously set off by pins; but instead of placing the line in the exact run of where the hedge is to be planted, the operator pins it down about 6 in. to that side of the run upon which the open ditch is to be made. He next proceeds to level and clean the surface of the ground of all the weeds, to the breadth of about 24 in., all along the run or rough hedge-line, as far as his line has been stretched; and having done this, with the common ditcher's shovel (Fig. 126), in a manner corresponding with the rising or falling of the ground in the run of the hedge, but levelling up or reducing any little inequality, he next proceeds to mark off carefully the edge of the ditch upon which his line was first stretched. In doing this, the operator turns his face to the side where the ditch is to be formed, and with his foot he forces the spade somewhat deeply into the ground, cutting the surface exactly all along by the line. The cuts should not be made perpendicularly with the spade, but with a considerable slope, in order to form part of its side, as exhibited in Fig. 125, where *b* represents the point upon which the line rests, with the slope of the ditch under. When he has finished the cutting of the one side, he will shift his line 4 ft. to the opposite side, in order to form the other side of the ditch, as at *g*, care being taken to make the second cut exactly parallel to the first; and in the act of cutting he must again turn his face to the ditch, in order to form the opposite slope. Both sides of the ditch being marked off, the operator next raises with his spade the turf, or whatever the soil covering may be, which has already been cleared of weeds, and the outer edge of which he first marked off at *b*; lifting this up, he turns it upside down upon the part now termed the bed, as at *e*, which he formerly levelled for the planting of the hedge, and upon which the roots of the young plants are to be laid. In doing this portion of the work, 6 in. of the level part must be left between the side of the bed and the edge of the ditch; this is termed the scarcement, and is meant to support the bed firmly, as well as to prevent the rolling down of loose earth from the bank *a* into the ditch *c*. Hence the operator, in lifting the soil from the

Fig. 126.

Ditcher's shovel.

edge of the ditch in order to make up the plant-bed, must keep it regularly 6 in. back from the edge; and in preparing the bed for the reception of the roots of the young plants, it must be made 3 in. above the level part or scarcement, upon the outside. This is done in a compact level manner, and must slope backwards from the outer edge at an angle of about 45 degrees (Fig. 125, *e*). This precaution is necessary in order that the roots of the plants may not be flat, but may dip into the earth, and that their tops may incline considerably upwards.

The bed and scarcement being completed in the above manner, and cleared of weeds, the next part of the work is to have the plants prepared for putting in; and as it is presumed that the plants, of Thorn and Beech, for example, have been brought forward in due time and sheughed or put temporarily into the earth by the roots in a dry part near the work, the operator will now proceed to plant them. Before putting them into their bed, he will, with the **pruning-shears** (Figs. 127 and 128), and not with an axe as many carelessly do, cut every Thorn plant down to within about 4 in. of the top of the root, or, in other words, leave only 4 in. of the stem of each plant. But with regard to the Beech plants, if any are to be planted among the Thorns, they must not be cut at all, not even the tops; for they do not establish themselves well if cut back at this stage, and Beech plants of from 8 to 12 in. high may easily be used for hedging purposes. Having everything thus prepared, the planter will take a few Thorn and Beech in his left hand, and with his right he will lay the plants upon the slope or bed prepared for them, putting in successively 2 Thorns and 1 Beech, at the distance of about 10 in. plant from plant. In laying the plants upon the bed, the top or cut part of the Thorn may be made to project over the outer edge of the bed about 2 in., this part will set away young shoots to form the hedge; but the Beech must be allowed to have all their top part lying out, with their roots upon the same level with those of the Thorns.

Fig. 127.

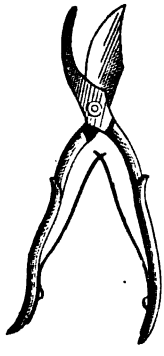
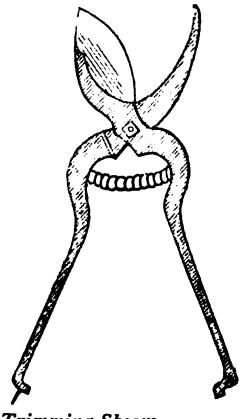


Fig. 128.



Pruning or Trimming Shears.

As the planter thus proceeds to lay out the plants upon their bed, another workman follows him to collect the finest of the soil from the

part of the ditch opened in making the bed, and to put it upon the roots of the plants, covering them very carefully, and taking care not to displace any of the plants while lying in their uncovered state. A third man also follows, to add another spadeful of earth from the surface of the ditch all along on the top of that put on by the second man. This second spadeful will be enough to cover the roots securely; and when this is finished, the whole of the soil thus put upon the roots of the plants should get a slight tramping with the feet in order to make the plants secure in their place, and to bring the soil in intimate connection with the roots. This having been done along the whole length of the line, all the earth contained in the ditch *e* is then thrown out and made to form the bank above the roots of the plants, in the shape exhibited in the figure at *a*. The ditch is generally made 4 ft. wide at top, 15 in. wide at the base, and 2 ft. deep; and the size of the newly formed bank, which is made from the earth taken out of the ditch, will be nearly 2½ ft. deep at the point above the plants at *a*, and from 4 to 4½ ft. wide at the base. After the earth has been all thrown out and the ditch is properly formed, with the sides smooth and the base level, the bank should next be shaped to nearly the same slope as the edge of the ditch under it. But as it is formed of loose earth, it is better to keep the slope of the bank a little lower than that of the ditch; and in order to prevent any of the loose earth tumbling into the ditch from the bank, it should be tramped down and made firm as the work proceeds. When the whole is finished, it should receive a firming with the back of the spade, so as to keep it all firm and smooth above.

In the finishing, the level scarcement ought to be left in a clean and neat manner, without any roughness lying upon it; the tops of the Thorns should all project regularly, and the soil be made firm about their necks. In this manner the whole line of hedge is to be formed, one line-length after another; and when all has been finished, a paling or line of barbed wire ought to be put up on the outside of the ditch, in order to protect the young hedge from the inroads of cattle. The paling or wire fence will require to be kept good until such time as the hedge becomes a proper fence of itself. On the average this will probably be in about seven or eight years.

The above method of growing hedges is well adapted to land of a wet character, or rather where the draining of the land has not been attended to. No Thorn hedge will succeed well unless the ground upon which it is planted be rendered dry; therefore, if the ground where a hedge-fence is to be planted is either not naturally dry or not made so by artificial drainage, the above plan must be resorted to. Besides,

it often happens that in the laying out of ground for a new plantation, the drains in it require to be run into some large ditch, acting as an outlet for the water. When all other circumstances correspond, this system of fencing with a ditch answers well; and in such a case, the ditch requires to be placed next the wood, with the hedge and bank outside, and with the paling or wire fence upon the outer tail of the bank, as at *f* in Fig. 125.

Another method of forming live-hedges is that of planting in the surface-soil without any ditch whatever. In all cases where the land is either naturally dry or has been rendered so by artificial drainage, and where there is at the same time no necessity for any ditch as an outlet for water from drains, &c., made in the neighbourhood, the more expensive system of planting bank-and-ditch hedges is unnecessary, and it suffices simply to plant out in the line of fence required. In planting a hedge in this manner, the ground should be trenched 4 ft. wide by 24 in. deep in the line of the hedge to be planted; and in the act of digging all root-weeds should be carefully picked out, as their eradication afterwards has a tendency to disturb the roots of the plants too much, and to check their growth by allowing the sun and wind to dry up the soil. When the whole length of the ground for the intended hedge has been thus prepared by trenching and cleaning, it should be made level to the eye in the first place. When once the ground seems to be nearly level, the line is stretched rather tightly along the middle of the hedge-line, in order to ascertain whether it is really level or not; for where the ground is hollow the line will be above it, and where the ground is high the line will be lying too close upon that part. The line being thus tightly set, the forester should work himself sideways along it, keeping the cord right under the middle of the soles of his feet; and by thus treading the earth firmly, walking sideways all along the length of the line, he firms down the soil to a distance of about 5 in. upon each side of the rope. Coming off at the end of the line, which may still be allowed to remain on the ground, any inequalities caused by the feet in walking along are made up with fresh soil, the new surface being beaten down with the back of the spade, in such manner as to keep about 7 or 8 in. in breadth level on the one side of the line, and only about 2 or 3 upon the other. This having been done, an opening may next be made to a depth of about 9 or 10 in. with the spade upon that side of the line which has the least level ground upon it; but the depth may vary according as the roots of the plants may require, care being, however, taken to have the opening neatly cut by the run of the line. The plants, prepared as formerly stated, are next put in along the side of the firm level edge, the stalks of the Thorns being kept about 2 in. above the surface, and the Beech plants all the height, as formerly stated. The

earth is then filled in, and the whole is made firm and level. This concludes the work of planting the hedge.[1]

In comparing these two methods of planting hedges, it may be remarked that by the latter system the plants come much sooner to useful size than when planted on the edge of a ditch; and therefore it is the more economical method of hedging. And there is another important benefit attending this mode of planting hedges, which gives it still greater advantage from an economical point of view, for it takes up less ground in the subdividing of land. Where there is a hedge and ditch, much useful land is occupied; but where there is no ditch, the least possible quantity of land is taken up by the fence. In choosing between the one system or the other, much depends upon the various circumstances of each case. When hedges of the bank-and-ditch kind require improvement, this may often be effected by putting drain-tiles into the ditches and filling them up, if the Thorns have become stunted and unhealthy from neglect. This not only improves the unsatisfactory condition of the hedges themselves by the additional supply of new soil about the roots, but it also gives back the land for a more economical agricultural utilisation.

In all cases of preparing soil for the reception of plants intended for a hedge, good earth should be added where it is naturally poor and bad upon the line; for if this be not attended to, the hedge will come away unequally, springing up strongly where the land is naturally rich and good, and weakly where it is poor and bad. Where it is found necessary to improve the natural ground on the line of a new hedge, this cannot be better accomplished than by carting fresh and good loam from a distance, and by adding it in considerable quantities to the natural portion, and of course mixing them well together.

Lime is sometimes applied to the bed of a young hedge. And in moderate quantities on strong land, or on land having much vegetable matter in it, it has a good effect in causing more rapid humification, and thereby indirectly stimulating the plants to much quicker growth and development; but, further than this, no manure should be applied, as good fresh soil, applied with perhaps a mixture of lime, is always more conducive to the health of the plants than any species of vegetable manure.

The plants used for hedging purposes should never be planted closer to one another than 10 in., nor farther apart than 12 in. Plants put in much closer than the former distance grow up weakly, and soon exhaust their strength; whilst those put in at a greater

[1] Additional information about hedging, from the agricultural point of view, will be found in Macdonald's edition of Stephens's *Book of the Farm*, 1893, pp. 215–230.

distance than 1 foot apart are long in closing up so as to become a good practical fence. From 10 to 12 in. apart appears to be the most suitable distance for plants growing healthily in a hedge, and for their becoming strong enough to resist cattle, which is in most cases the main object in view.

The best time of the year for planting hedges, whether Thorn or Beech, is either in autumn (November), or else towards the end of winter (February). In either case, the ground should be properly prepared early in the autumn, in order that it may have time to ameliorate and subside, as any subsidence occurring after planting makes the line look straggling and uneven.

Tending of Hedges.—This is a matter of the very greatest importance to the welfare of such fences, seeing that many of the plants may soon die off from the want of due care being bestowed upon them. The great points to be observed in the management of live hedges are regular cutting and cleaning. Supposing that a young hedge has been planted any time between the beginning of November and the end of February, it will during the following summer make considerable shoots. The Thorns will, in all probability, have made shoots of 12 in. on the average; but if Beech plants are used, they will have made comparatively little progress, because they naturally require a longer period to establish themselves in the soil. If, however, they appear fresh in the leaf, and have made even from 2 to 3 in. of young wood upon the top shoots, this is quite satisfactory. If the Thorn plants had not been cut down, they would very possibly not have made a greater growth than the Beech; but had the Beech been cut down in the same manner as the Thorns, it is not improbable that about the half of them would have died. This explains the reason for cutting the one and not the other; for the growth of the Thorn plant is stimulated by severe cutting, while that of the Beech in its young state is interfered with, particularly as regards the old wood.

Fig. 129.

Many foresters are in the habit of cutting over in autumn the shoots of the first year in young Thorn hedges; but this practice seems open to objection. In all cases of hedge-culture, it seems preferable to allow the plants to remain uncut until they have two years' wood upon them, and until they have their roots thoroughly established; and when they have arrived at this stage, they may be cut back to about 9 in. high, and also dressed closely in the sides about the month of November. During the first two summers, therefore, after the hedge has been first planted, all the attention necessary to be bestowed upon it is that of keeping it clear of weeds, which is simply done with the hedge-spade (Fig. 129),

[illegible] hedge-cleaner (Fig. 130); this is [illegible] handle, and the spade itself is [illegible] 9 in. long, excluding the hose, [illegible] same length as the spade. This [illegible] sharp upon the edge, and is [illegible] the same manner as a gardener [illegible] Indeed, many use a small [illegible] 131) instead, which answers the [illegible] A common rake should be used [illegible] after the hoe, where this is con- [illegible] The hedges should be cleaned [illegible] months of June and August.

[illegible] th of weeds be checked, they inter- [illegible] ment of the lowest branches, and [illegible] edge thin at the base; hence the [illegible] carefully weeded. By bare-fallow- [illegible] of all, and clearing it of all rank [illegible] danger of the base being choked [illegible] nished. The bad effects are pic- [illegible] in Fig. 132, in which *a* is the [illegible] the weeds interfering with the lower [illegible] Thorn.

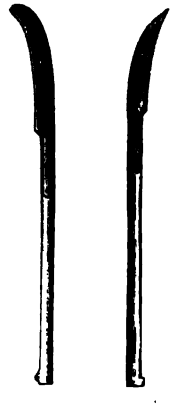
[illegible] the purpose of having a firm and [illegible] the ordinary efforts of cattle of [illegible] is to keep the ground immediately under the hedge-plants clean from all weeds. This secures the health of the hedge in the under part, and allows it to spread down to the very ground; whereas, when weeds are allowed to grow under the hedge, it soon becomes bare and naked of branches, and proves open and weak there. In the cleaning of hedge-fences, it is also an object of great importance to keep the ground clear of weeds for at least 1 ft. beyond the drip [illegible] current of air passing through, [illegible] re to become bare and weakly [illegible] been regularly kept for a few [illegible] one halfpenny a rood per year [illegible] if the hedges have been allowed

to become dirty from want of attention, and if they have not been cleaned for several years, as is too often the case, they may cost four or five pence a rood to put them in order, even for one cleaning, without reckoning the injury that may be done to the fence. Although it may indeed cost a proprietor a few pounds each year to keep his hedges clean, still, if the work be neglected for three or four years, a very much larger sum may be eventually required to put them right if once they be allowed to run wild, apart from the consideration that, unless they are kept clean, hedges are of little use as fences.

When the hedge is to be raised for the purpose of forming a firm and compact fence capable of resisting cattle, the great point is, next to keeping it clean, to cut the fence yearly in some standard form; and this form must in all cases be regulated by the situation in which the hedge grows, by the object in view, and in a great measure by the taste of the proprietor. Unless hedge-fences are trimmed annually, the hedge soon begins to get bare at bottom and over-bushy at top; whilst it very soon becomes loose and open, and without firmness or compactness to resist cattle, as a fence ought to do. But when regularly trimmed and cut, the hedge is close in texture from bottom to top, and is healthy and long-lived as compared with hedges that are not regularly trimmed.

In trimming and training up young hedges, the plants may be allowed to remain uncut till the end of the second year, when, for the first time, they should be cut over about 9 in. from the surface, at the same time also cutting in the sides rather closely. The implements for this purpose are the hedger's **switching-bill** (see Figs. 133, 134), and never the shears, which some use in cutting young hedges. Shears can also be used for cutting a hedge, but they are apt to make a rough wound, which is generally attended with the loss of a bud or two under the wound; whilst the switching-bill, on the contrary, makes a clean cut, and no bad consequences follow. The switching-bill has a curved blade 9 in. long and 1½ in. broad, a helve 27 in. long, and a total weight of about 2½ lbs. only. It is used with a rapid upward, slightly slanting, stroke. A hedge that is **switched** or pruned by the use of the bill is also in all cases trained up more closely and firmly than one cut with the shears. In cutting a hedge for the second time, which will be when it is three years old, it should be cut down to about 15 in. in height, making it regular on the top-level; and in the side-cutting only about 2 in. of a spur of the last year's growth should be left. This is continued each year successively until the fence has

Fig. 133. Fig. 134.



attained its full size; at each successive cutting it is left from 4 to 6 in. higher, as the strength of the plants may indicate, and at least 2 in. broader on each side than it was when cut back in the previous year, until it is 4½ ft. high, after which period it should be cut back each following year as nearly to the old height as possible. For every forester must be aware that, in cutting hedges, they will increase in height and breadth under the best system of cropping, seeing that, in the act of cutting off the annual shoots, there is always a short piece or spur left at the base of every young shoot cut. So much, indeed, does this increase the bulk of the best-kept hedges, that in course of time it is found necessary to reduce them in size.

A hedge, however well kept, in the course of a number of years generally outgrows itself, from the cause above stated; and this state of a hedge is easily known by its becoming loose in habit, rather open and overgrown in appearance. Now there is no better way of renewing a hedge in this state than cutting it in, or what is termed **ribbing** or **breasting-over**; and this ribbing consists in stripping the hedge of its side branches, and allowing it to make new wood all over. But in doing this caution must be used; for where hedges are ribbed without due caution, they die down to the surface, and consequently have to be cut over at that part, and allowed to grow up anew from the old roots.

In the ribbing of a hedge, therefore, the following points must be kept in view. When it is found necessary to **ribb** in a hedge, it must be considered whether the situation be an exposed one or not; and if the situation be not unsheltered, nor in a part of the country exposed to the sea, nor more than 600 ft. above the level of the sea, the ribbing may be done at any time from November to the first of April, as may be most convenient. In doing the work, the operator will use what is termed the **ribbing-bill** or the **breasting-knife** (Fig. 135), which is much stronger and heavier than the switching-bill, and has less hook upon the point; it has a blade 7 in. long and 2½ in. broad, a helve 2½ ft. in length, and weighs in all about 6 lbs., which is more than twice heavier than the switching-bill. In ribbing the hedge, the hedger cuts off all the lateral branches *upwards*, to within about 4 in. of the main stems upon each side; and the hedge over all should also be reduced in height to about 3 ft. In order to have greater freedom, the hedger may use the light switching-bill first of all, and then the heavier breasting-knife when all the smaller shoots have been trimmed away, the prickles on which might otherwise injure his hands. It should also be borne in mind, in the case of ribbing in a hedge, that if sheep or cattle are in the habit of grazing in the

Fig. 135.

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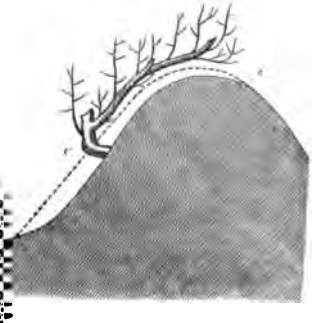
Fig. 136.



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light **hedger's axe** (Fig. 137) is used, a light 3 ft. axe weighing only about 3 lbs. The twigs being first removed by the switching-bill, the axe is then brought into play. The cutting strokes are made upwards, and the split portion is cut off by a downward blow of the axe. When this is completed and the brushwood has been removed, the ground should be well cleaned and dug to the extent of about 24 in. upon each side of the hedge-line, so as to aërate the soil, and all gaps among the old stumps should be filled up with new or young plants. In filling up with new growth among the roots of old Thorns, it may be observed that young plants of the same sort should not, as a rule, be used in such cases; for, owing to Hawthorn being a **light-demanding** species of small tree, the new plants seldom succeed well where overshadowed by old Thorns. But in all cases of this nature Beech plants, or Hornbeam, or Spruce, may be used, as these are all **shade-bearing** species, which can thrive fairly well under the shade of the old Thorns.

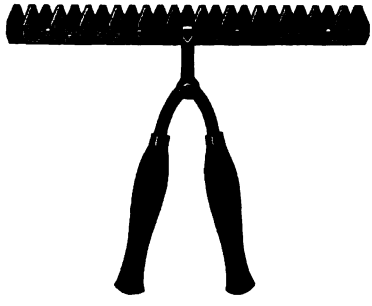
Fig. 137.

Work of this kind may be done during open weather at any time throughout the autumn, winter, or early spring; but in order to have the hedge continue sound and prove a good fence afterwards, it must be kept clean, protected, and regularly switched, as has been already stated. The directions above given for the renewal of old and neglected hedges will be found to answer very well where the Thorns are comparatively healthy, and are not already much injured in any way; but with regard to such old hedges as have been very much neglected, and are in consequence very straggling, the treatment recommended will not always enable the plants entirely to recover so as to form a good healthy hedge and a stout fence. Where, therefore, the plants forming a hedge have been allowed to assert their natural desire for enhanced individual growing-space, they should be dug out altogether, and a new hedge planted instead. If the new line of fence is to occupy the same ground as the old line, the soil should be thoroughly prepared by trenching and aëration of the soil to a breadth of 5 ft. and a depth of 2 ft. It is also sometimes advisable to bring good soil from an adjoining field, and after filling up the trench with this, to plant the young hedge in it in the usual way. When the soil has become exhausted and deteriorated, no other method is likely to secure a thriving hedge-fence under the circumstances.

Hedge-Clipping Machines.—Several machines have been introduced for the clipping of hedges, so as to save labour and expense. One of the simplest of these is **the Ridgway hedge-cutting machine**

(Fig. 138), which has been in use for about a dozen years, and is said to work well and expeditiously. It is constructed on a similar principle to the common reaping-machine, and with handles the same as those of a pair of hedge-shears. Both motions of the machine cut the hedge, by which plan the work can be done more quickly than were it only to cut one way. In using it, the left hand guides the machine to its work, while with the right one the handle is moved backwards and forwards, giving it the full play of the top-knife. In this way a man can move forwards along the hedge at a slow pace, trimming the shoots as he goes, and can either cut lengthways with the hedge, or from near the bottom upwards. The best way is first to cut, horizontally, the lower part of the hedge; and afterwards the upper part can be cut in a perpendicular manner. This machine may be recommended for use upon evergreen hedges that are kept regularly trimmed, as practical experience has proved that it is well adapted for such work. It will cut twigs of a fair thickness, but should not be used except upon hedges that are kept regularly cut every season. It may be mentioned that only the top-knife requires sharpening, and that this may be executed with a file in the same way as is done in sharpening the knife of a mowing-machine. The machine can be had to cut either 1½, 2, or 3 ft. in width, as may be required; but for general purposes that which cuts 2 ft. in width will be found to be the most useful.

Fig. 138.



Endeavours were made about 1882 to introduce hedge-cutting and trimming machines drawn by two horses in a similar fashion to a reaping or mowing machine. That which was manufactured by Messrs Richard Hornsby & Sons, Grantham, is shown in Fig. 139. The following is Messrs Hornsby's description of its action:—

"The machine is mounted on two road-wheels of large diameter, to secure light draught. Both wheels are employed in driving the working parts, the motion being communicated by an arrangement of gearing to one of a pair of knives, similar to the knives of mowers and reapers, but larger and of greater strength. These knives are carried by a sliding-bar projected from the side of the machine. This bar, with the cutting apparatus, is so arranged as to be capable of ready adjustment to suit different circumstances; the entire machine, when set for work, being under complete control of the man in charge, who rides upon a seat conveniently placed for making all necessary adjustments. The cutting apparatus can be raised to any required height, to suit high or low hedges, or the level of the ground on which the machine may be travelling. It can also be set at any required

to reduce its height or alter its shape, e may be cut from the same side, so which is most convenient. The side of cut first, and then the bar lifted over rsed, so as to cut the other side. The h, by setting the cutting-bar straight dge is required to be left. The hedge h at bottom, and of any height."

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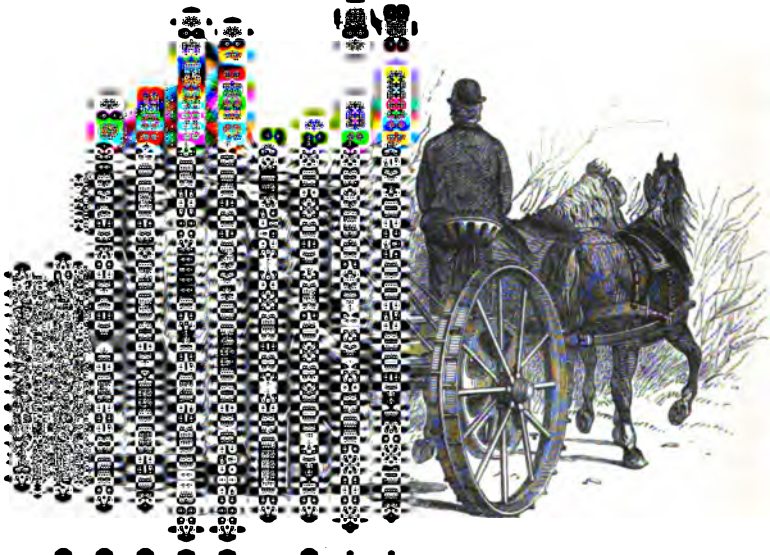

e so little practical demand for & Sons have discontinued its it here merely the for the sake of t out that such machines have to be practically successful.

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Hedge, an end section of which is s of all others the best form for a t to prevail; and it is, moreover,

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Fig. 141.

und throughout all the nd and Scotland.

nd section of which is form to be found in all it is very well adapted. approached too close or apt to get out of order, and good management. are to be seen in the ivated districts of the

Fig. 143.

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ther as a wood or a field fence; nt out its unsuitability for general ence of this kind round a garden, s a general country hedge, it is itself, and to become straggling,

44) is an admirable fence for plea- -parks, but is not at all adapted d-fence. For it is plain that in of a hedge for agricultural and ses, it is always of the first im- what is most useful and econo- hat which is most ornamental. It rear up a hedge in the square ying district merely for the sake aste, when it is well known that not answer. Yet such a state of ten be observed. From the prac- , the wedge-shaped and the full- that can be adopted for general merely ornamental forms, though extra shelter upon home grounds, re and attention.

lex Europæus) is one which is often North of Scotland and in Ireland dly worthy of being recommended, apt to be injured by severe frost ir best condition the Furze-hedges they are extremely objectionable Almost any case in which Furze- better met with a well-managed be longer-lived, more ornamental, n every point of view.

hedges, as generally practised in y understood by reference to Fig. but 4 ft. wide at top, and sloped in It will also be observed that the ide is more flat or acute than that make the plantation side of the itch is made about 3 ft. deep from ken from the surface of the ground the plantation side to about the

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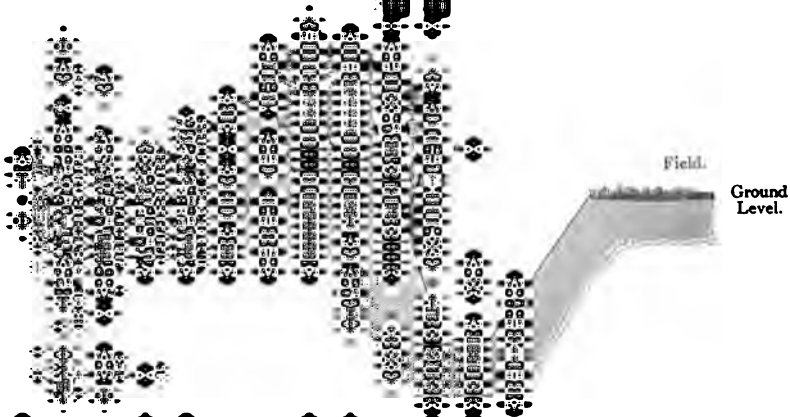

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ie over the slope, as at *c*,
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From the physiological
the plants must be greater

in number just before flowering than after they have been partially utilised in the process of inflorescence; hence, theoretically, it would seem preferable to trim the hedge a short time before the flowering-buds begin to open—that is to say, before any considerable proportion of the reserve nutrients are carried to the flowering twigs for the nutrition of the flowers.

The Holly-Hedge (*Ilex Aquifolium*) makes an excellent and ornamental evergreen fence where only required as a screen to hide some parts of the ground from view, or where shelter alone is wanted; but from the nature of the plant it is not adapted to form a strong fence against cattle in fields. One advantage of the Holly is that it grows well under the shade of trees; and from this it is fitted to make a hedge on many situations where few other plants would succeed. To grow it well, however, it requires to be planted on a good, dry, light loam, having an abundance of humus or organic matter in it. The Holly cannot thrive luxuriantly in any soil that is not rich in humus; but it does very well on a sandy moss or a soil chiefly composed of well-rotted leaf-mould. In forming a hedge of Holly, therefore, this should be kept in view; otherwise failure may too often be the result.

The Common Portugal Laurel (*Cerasus Lusitanica*) also makes a very ornamental evergreen hedge, but is only suited for this respect in situations which are not exposed. Being indigenous to the Continent of Europe, it does not thrive without shelter, and is therefore not adapted to make a fence in fields. It is, however, not particular as to soil, but seems to accommodate itself to most land, provided it be sheltered from cutting winds.

For small grounds, an outer fence of Thorn and an inner hedge of Laurel are often very effective. The Thorn-hedge then shelters the inner hedge of Laurel, and the latter remains in full leaf during the winter. In such cases there must of course be a sufficient space left between the two hedges to admit of easy trimming and tending, and to give each hedge a sufficiency of light, air, and warmth.

The Common Yew-Tree (*Taxus baccata*) is also well suited for ornamental hedging, though otherwise it is worthless as a fence, not only on account of its naturally slow growth, but also because its habit is of too soft a character to resist large animals. Another objection to its being grown where cattle graze is, that its leaves and berries are well known to be poisonous to them. It thrives best on soil of a limy character, and can stand shade uncommonly well. It is also a class of fence that bears clipping well; hence it may be utilised for fantastic gardening.

Boxwood (*Buxus sempervirens*) is another plant also well adapted for ornamental hedging, but which cannot be made use of to advantage for field or other fences.

The Privet (*Ligustrum vulgare*) is a plant of rapid growth, and well suited in some respects for hedging. But it is not a plant suited to make a strong fence as a hedge of itself; for it is not only of too soft and pliable a nature to resist pressure, but it is also of such a free and rambling growth that it requires a good deal of attention in order to keep it in any degree of tidiness or shape. It is a useful plant, however, for the purpose of filling up gaps in old hedges of Thorn, where it is sometimes very difficult to get any other plant to grow, so as to fill up a spot where an old Thorn plant has died off. For this purpose it may therefore be recommended along with the Beech, Hornbeam, Spruce, or Silver Fir. In using them thus, it is only necessary to dig out the old roots of the dead Thorn plants, and insert young roots of the Privet instead, say at 6 in. apart. Small gaps in old hedges may often be efficiently repaired in this way; and as the naturally rapid growth of the Privet is promoted by the shelter and support of the old hedge, gaps may be filled up by it in a complete way, even within two years after planting.

Barberry (*Berberis vulgaris*) is another plant frequently used for hedging; but as it is very apt to die under severe pruning, which is indispensable in hedge-culture, it does not generally answer well.

For another reason the use of Barberry as a hedge-plant is to be avoided; it is believed that it tends to propagate the rust or smut of wheat due to *Puccinia Graminis*. During the summer of 1893, the editor noticed the prevalence of Barberry in hedges near Pitlochry, in Perthshire, between fields of oats and wheat. Inside of the fields themselves large timber-trees were standing, within the reach of whose heavy shade and long shadows the crops were poor, and the soil not utilised to its fullest agricultural capacity.

Wherever the Barberry occurs on agricultural land, it should be rooted out habitually.

Hornbeam (*Carpinus Betulus*) is a shade-bearing plant well suited to hedging. Indeed, for hedging purposes it is only surpassed by the Hawthorn and the Beech among all the hedge-plants. Excellent hedges of this plant may often be found on fresh, light sandy soil, on which Thorns would not thrive. The plant attains a third-rate tree-size, and therefore forms a strong and permanent fence as a hedge when dealt with in the common way.

The Birch (*Betula alba*) is sometimes found forming hedges on poor thin soils having a high altitude. It stands pruning well, and when properly trained and kept in, it makes a fair and permanent fence.

The Elder (*Sambucus nigra*) is much used for hedging in the North of Scotland; but its hardiness and quick growth are its only recommendable qualities, as it is ill adapted to produce shelter in winter and spring. As a hedge-plant, even for high and exposed

situations with a poor soil, the Beech, or even the Birch, is much superior to the Elder. When a screen is quickly wanted on an exposed part, however, it is certainly preferable to any other plant for this special purpose, as it will generally make a growth of from 4 to 6 ft. in one season.

The Myrobella or **Cherry-Plum** (*Prunus Myrobalana*) is said to be an excellent plant for making hedges. It grows well on very poor soils, and stands cutting as well as the Hawthorn. It is said to thrive well within the influence of the sea-breeze. As it has been highly recommended by many for hedging purposes under such conditions, its merits should be tested by foresters who may be inclined to give it a trial.

Hedges of Spruces, Silver Firs, and Juniper answer well for ornamental purposes, as they stand cutting and look well throughout the winter; whilst, as shade-bearing species of trees, they maintain considerable density. Constant trimming is requisite in order to prevent them sending up any leading-shoots.

In rearing hedges from the plants above referred to, they should have the land prepared for them in the way recommended for the cultivation of the Hawthorn and Beech hedges; and in planting them in the lines, no pruning should be allowed on the Holly, the Portugal Laurel, the Yew-tree, the Box-tree, the Hornbeam, and the Birch. They should also be allowed to stand uncut for a period of two years after planting, and until they shall have become properly established in the soil, after which they may be dealt with in the usual way. But plants of the Privet, Elder, and Cherry-plum, when used for hedging, should be cut over at first in the way recommended in respect to the Hawthorn, and should also be pruned well during every successive year.

In the cultivation of all hedge-fences, as little digging should be allowed as possible; for this operation invariably disturbs and destroys the roots. Where the roots are interfered with by such injudicious management as the practice of frequent digging must be considered, the hedge-plants become of weakly constitution, gradually lose their vitality, and consequently die off. The only digging permissible in the management of hedges would be in the case of such as had to be cut over, after the operations of clearing had been neglected for some years. In such cases, digging in order to attain cleanness is indispensable; but where hedges are well kept, it is never found necessary to **dig**, but only to hoe.

Pruning of Deciduous Hedges.—Hedges formed of **deciduous** plants should never be pruned till the young shoots of the season are matured; for if they should be cut before this, the plants suffer in health. This point is generally too little attended to; hence it is one of the

most frequent causes of broken gaps and straggling growth with regard to a very large number of the hedges of this country. In the economy of a plant, the root draws up food from the soil, and the leaves prepare it for the healthy nourishment, growth, and development of the complete organism. This being the case, how then can those deciduous hedges grow healthily whose root systems are annually disturbed by digging, and whose assimilative and constructive processes are interfered with by switching in summer, during the period of most energetic vegetation? All such mismanagement of this class of hedges is a direct interference with the vital processes, and is therefore reprehensible. Hence the hoe only should be used in cleaning; for a proper use of the hoe will not injure the roots of hedge-plants. No switching or pruning should be done except in autumn, when the leaves have performed their functions and vitality becomes dormant, or else during the early spring before the active period of vegetation returns.

Pruning of Evergreen Hedges.—The pruning of hedges formed from evergreen plants should preferably be carried out in spring; although, of course, the exact time may vary with the nature of the season and with the respective kind of plant of which the hedge may be formed. But, generally speaking, the month of April may be taken as the best time for the pruning of all evergreens.

Maintenance of Hedges.—If hedges be well attended to while young, they are not expensive to maintain afterwards. It is neglect at first that principally gives rise to expense later on in connection with them. On well-managed estates in different parts of the country, hedges are kept well cleaned and pruned, and maintained in every respect in good order, for one farthing per yard per annum, or at the rate of £1, 16s. 8d. per mile, which certainly cannot be considered expensive. But at the same time it may also be remarked, that on other estates, where the hedges have been in bad keeping for some time previously, they sometimes cost the proprietor nearly ten times this sum.

The Building of Stone-and-Lime Walls as Sunk Fences.—Stone-and-lime walls are most frequently built for the purpose of policy-fences or for sunk fences. When walls are erected for the protecting of home or policy grounds, their dimensions must in all cases be regulated by the views of the proprietor; for if the proprietor merely wish to have a wall erected in order to protect his home-grounds from the inroads of cattle, it may be built 16 in. thick at bottom, and 12 in. at top immediately under the cope; or the cope may be 10 in. high, pick-dressed, and projecting 2 in. over the building on each side; and the whole height of the wall may be 5½ ft., including the cope.

If the proprietor wish to have a stone-and-lime wall erected, sufficient to protect from the inroads of people who may be apt to trespass in the neighbourhood, as well as to retain deer that may be kept in the home-parks, he would require to build it at least about 7 ft. high; and a wall of this height would require to be 18 in. thick at bottom, and 15 in. at top immediately under the cope, which would require to be at least 12 in. high. A great point to be attended to in the building of stone walls for fences is to see that no soft or bad stones be used, particularly in the outer part of the building; for if such be used, then the wall is sure neither to last long, nor to give anything like permanent satisfaction. Hence the forester, or the land-steward who may be intrusted with the inspection of such work, should be most careful to see that this condition is enforced upon the contractor. Another point to be observed in the erection of all stone walls, whether these may be built with lime or not, is to see that all the stones used in the building be laid upon what is generally termed their natural bed—that is, the natural seams in the stones taken from stratified rocks should lie horizontally in the building, and not vertically.

Sunk Fences.—The sunk fence is one which, from its very name, is meant to be hidden. It is a fence often to be met with upon good estates of old standing, and about a hundred years ago was very much introduced in the laying-out of grounds and home-parks. But now, since wire-fences have come to be generally used, the erection of sunk fences is fast falling into disuse; hence they are very seldom introduced, except where they may answer some special and particular purpose, as on the slope of a hill or brae, for which the sunk fence is admirably adapted, and is of all others the most fit and suitable. But generally as regards the matter of enclosures, the use of wire-fencing of a more or less ornamental description has to a very great extent, and deservedly so, taken the place of sunk fences in policies and on the residential portions of large estates. For a sunk fence is, in regard to lightness, or airy and natural appearance, much inferior to the wire fence, and is, at the same time, much more expensive in the first erection; hence, from a purely ornamental point of view, even sunk fences ought never to be made upon any level piece of ground where the wire-fence can be erected. But upon any steep sloping bank, where it is desirable to have a fence, the sunk fence may be recommended, with a low wire-fence on the top to complete it. As many proprietors are still much in favour of sunk fences, however, it seems desirable to detail here the operations of erecting them.

They are made with a wall upon one side and a paling-fence upon the top. Their construction will perhaps be most easily understood by referring to the following figures.

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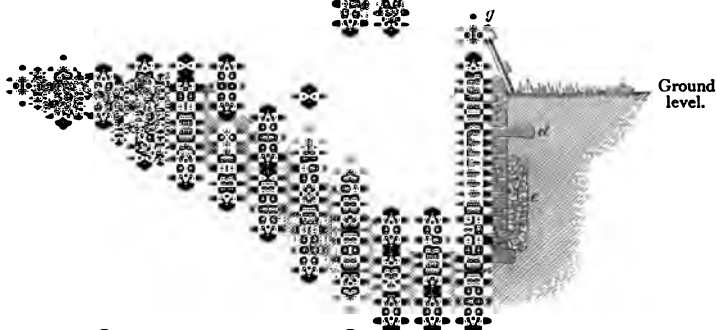

built of the best stones
The cope-stone should
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about 8 in. wide should
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e water, and consequently
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b, holes about 3 in. wide
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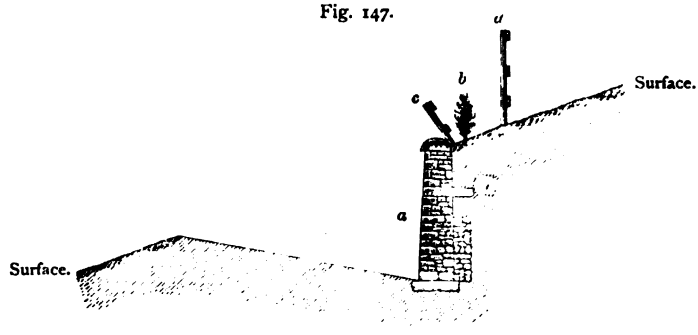
through the thickness of
e with the drain behind.

In order to make the fence more effective for the field upon the side of which the wall is built, a low paling or wire-fence ought to be erected immediately behind the cope, and made to project over the top of the wall, as seen at *g* in the figure; it need not be more than 2 ft. high, and may be either made of wood or iron, as may be found most expedient. Many have a hedge planted upon the top where the paling is shown in the figure, which is indeed a great improvement where shelter is wanted upon a high part. This is, however, not generally necessary with sunk fences upon level ground, where they are not meant to be seen, but only upon slopes where the situation is exposed. Fig. 147 will explain the nature of the sunk fence with a hedge, as adapted for high sloping ground, where immediate shelter is found of the greatest importance.

Sunk fences of the latter description, as represented in Fig. 147, are excellently adapted for a high-lying part of the country, upon the slopes of rising and unequal ground. The wall *a*, which is 4 ft. high

Fig. 147.



with cope, may be very properly built of stones, without the addition of any lime, if thought necessary,—excepting the cope, which should in all cases be put on with lime; under such conditions the wall need not be more than 14 in. wide at bottom and 10 in. at top. But if the wall be built without lime, it will not be necessary to make any drain behind, as recommended in the previous case, seeing that the water can perfectly well escape without it. The hedge *b* should be planted about 16 in. back from the top of the wall. In order to protect the hedge while in its young state from cattle upon either side, it is necessary to have a two-barred paling, *c*, upon the ditch side of the hedge, and a three or four barred fence, *d*, upon the upper side. There is a large extent of these sunk fences in the northern districts of both Scotland and England, which answer the purpose excellently; few fences are better adapted for a hilly country, where the line of fence runs at right angles with the slope of the ground. In the first instance, there is shelter produced for stock by the wall

itself, which is yearly increased as the hedge grows; and ultimately, when the hedge has attained its full height, a clothed appearance is produced, which gives a very pleasing effect.

It may further be stated relative to the building of sunk-fence walls, that it adds much to their strength to have them secured by what are termed **through-band stones**, as shown in Fig. 146 at *d*, and in Fig. 147 at *e*. These through-band stones should be put on about two-thirds of the height of the wall, with at least one to every 6 ft. in length, and should consist of large flat stones about 3 in. thick, and of a length sufficient to reach from the front of the wall to at least 1 ft. into the solid earth behind, into which they should be firmly bedded, in order to prevent the weight of the bank, if it should give way above, from pressing forward the masonry. Another point to attend to in the building of sunk fences, which adds much to the strength of the whole, is, instead of building the front of the wall perpendicularly, to make it lie back about 3 in. at the top; or, as masons term it, "the top should be 3 in. backwards off the plumb." This is indicated by the dotted line in Fig. 146, which shows the true perpendicularity; whilst the wall itself stands 3 in. back from this line at top.

Building Dry-Stone Dykes.—An extensively used fence in the high inland districts of Scotland, Ireland, and the North of England is the dry-stone wall. From the nature of the country in those high districts, stones are plentiful, and of course easily and cheaply obtainable; from which circumstance it is a fence much in use for all purposes. Stone walls or dykes have the effect of affording considerable shelter both to young plantations and to agricultural cropping as soon as they are erected for that purpose; and they are also of great importance in high countries, as giving immediate shelter to cattle in the adjoining fields, which is a great point in favour of their extensive use. This, of course, is not the case with a young hedge-fence, which requires from eight to ten years before it attains a sufficient height to produce any appreciable amount of shelter.

The dry-stone wall used to be built entirely without the addition of any lime or mortar to bind it, and consequently it was always apt to be broken down by any strong pressure, or by cattle coming in contact with it. But in later times great improvements have been effected in the building of walls by having the top or cope stones all put on and bedded in lime; this keeps the wall altogether in a more firm and compact state than when the old principle was adhered to of having no lime upon any part of the structure.

Dry-stone dykes are built of various heights, from 5 to 6 ft.; but the most approved height for general purposes may be said

to be 5½ ft. over all. General directions as to the proper manner of executing the work of building dry-stone walls are contained in the following **Specification**: and as they are of the most approved sort for work of this kind, such a form of agreement may no doubt prove useful to foresters and land-stewards in general, who may have occasion to arrange for and superintend such work.

MINUTE of AGREEMENT between A. B. on the one part, and T. P., residing at S——, on the other part, for erecting a March Fence between the Farm of Y—— and the Farm of O——, upon the Estate of A——.

First,—The stone wall to be erected under the present agreement is on that part of the line of march beginning at the present shepherd's house, and from said shepherd's house to the extreme summit of the hill.

Second,—The said wall shall be built according to the following specifications: The wall is to be 5 ft. 6 in. high. The foundation must be laid with large flat stones, which foundation must not be less than 34 in. over. The setting-off of building upon the same foundation must be 28 in., leaving a scarcement of 3 in. upon each side. At 30 in. in height, the wall to have a row of through-band stones, six at least to the rood of 18 ft. The wall to be built 48 in. of double, and the cope and coble to stand 18 in. At top of doubles, the wall to stand 18 in. across. The coble-stones to project at least 2 in. over the doubles. The cope and coble to be properly bedded, built, and pointed with lime, which must be mixed with the regular and proper quantity of sand. The whole to be finished in a sufficient and workmanlike manner, to the satisfaction of A. B., who is appointed inspector of the work.

Third,—The said T. P. binds and obliges himself to execute the whole of the work, in terms of the above specifications, at the price of per rood of 18 ft. lineal measure, and to complete the same before the first day of next, but with power to the inspector above named to extend the time for building as he may see proper and right.

Fourth,—The said T. P. further binds himself to uphold the said wall for three years from the time that the work is finished, and at the expiry of that period to deliver it over to the proprietor in a proper state, and to the satisfaction of the said inspector, or any qualified person who may be appointed by the proprietor.

Fifth,—The whole of the stones used in building the wall must be of good quality, and approved of by the inspector above named. And no crop of rock or wasting stones shall be used; and the contractor shall pay the tenants of Y—— or O—— for any damage they may sustain from quarrying or driving the stones through their fields or over their grass lands.

Sixth,—The contractor, on receiving full payment of the price, shall either find good security for implement of the contract, or leave in the hands of the proprietor the sum of sixpence per rood for the said period of three years. In witness whereof, these presents, written by A. B., are subscribed by the said A. B. at A——, the twenty-third day of May, in the year eighteen hundred and eighty, before these witnesses, W. M. and R. S.; and by the said T. P., at S——, upon the day last mentioned, before these witnesses, J. P. and A. H.

W. M., *witness.*
R. S., *witness.* . . . . . A. B.

J. P., *witness.*
A. H., *witness.* . . . . . T. P.

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there being no due solidity throughout so as to cause one stone to press upon another from side to side when the stroke is given. The inspector ought also to see that all the stones used are put or laid on their natural bed, and that every individual stone rests upon two lying under it, and never upon one.

The manner in which the building up of dry-stone dykes is proceeded with is easily intelligible from the accompanying illustration (Fig. 148), which exhibits the commencement of a dyke from where a gateway is to be formed. As depicted, the dyke is formed piece by piece within frames of the shape to be assumed by the dyke; and on undulating ground these frames are set up about half a rood or 15 yards apart.

Cost of Dykes.—The cost of erecting stone-walls of this sort differs in different parts of the country. It depends partly on the price of labour in the neighbourhood where the wall is to be erected, and partly upon the convenience of getting stones for the purpose. If stones are to be carted far from the line of fence, the expense becomes considerable; but when once the stones are laid down, the work should generally be done for about 6s. per rood of 6 yards, including the cope and coble well put on with lime. A wall 5 ft. 6 in. high, such as specified above, requires about twelve cart-loads of stones to the rood; and when the quarry is opened, and the nature of the stones observed, it will not be a difficult matter to calculate the quarrying, cartage, and building in any particular district.

In Stephens's *Book of the Farm*, 1893, Div. V. p. 231, the following remarks are made as to the cost of dykes:—

"A double-faced 3 ft. 9 in. dyke requires 1 ton of stones for 1 square yard of its face, so that 36 tons of stone are required for 1 rood of 30 yards long.

"The expense of quarrying that quantity of stones may be about 10s. the rood; the carriage of them at a reasonable distance beyond 1 mile is also 10s.; and the building commonly undertaken, when the stones are good, at 10s. also;—so that such a dyke costs 30s. the 30 yards, or 1s. for 1 yard in length, or £6, 9s. 6d. per cubic rood, or 3s. 7d. per cubic yard. The best way to contract for the erection of stone-dykes is by the rood of 36 cubic yards, when every temptation on the part of the builder to lessen the breadth, and make the heart of the dyke hollow, is removed."

The editor would merely note here that, if much of this unproductive expenditure cannot be avoided, Sylviculture in Britain must always remain heavily handicapped by the more rational and economical methods adopted with regard to Continental forests.

Dry-stone dykes are not nearly such picturesque objects in the landscape as Hawthorn hedges; but they are independent of climate, and therefore more suited to mountainous tracts where stones are usually plentiful. And when once the initial costs of erection are incurred, there should be no regular annual expenditure on maintenance and upkeep.

[illegible] **e-Fencing.**—In many [illegible] are not easily obtained, [illegible], it would not be advis- [illegible] ry neat and useful fence [illegible] g moorland districts.

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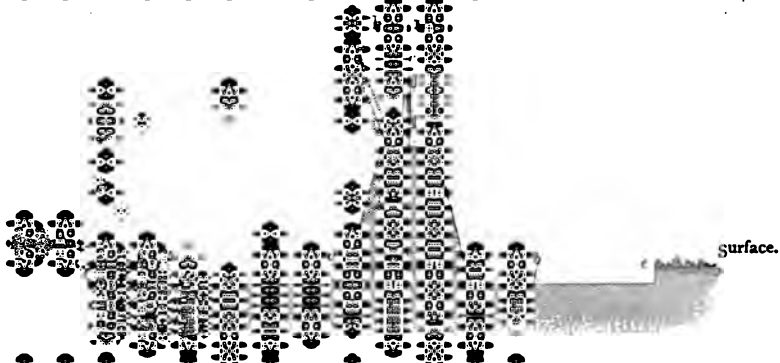
[illegible] ving been laid off by a [illegible] upon which the fence is [illegible] building, first measures [illegible] t *o*, to one side as at *a*, [illegible] round; then, stretching

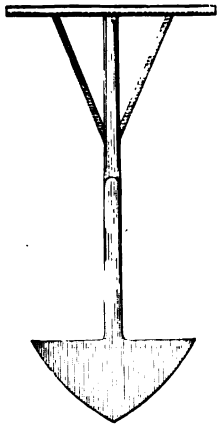


[illegible] will reach, he fixes the [illegible] same manner as at the [illegible] n the same side of the [illegible] nd *pinned* down exactly [illegible] next proceeds to edge [illegible] e, in order to form one [illegible] edging off the side of [illegible] he operator must cut the [illegible] field and his feet upon [illegible] so that the edge of the [illegible] able slope outwards, as [illegible] his sloping of the edge [illegible] wer a twofold purpose. [illegible] e, when laid on in the [illegible] ping upwards; and the [illegible] ing manner, lasts much

longer than it could do if it were cut perpendicularly. In the same manner the other side of the stance should be cut or edged, measuring 18 in. from the centre to the opposite side, and making the foundation 3 ft. wide over all, as seen from *a* to *a*. The foundation having been thus marked off, the operator next proceeds to measure outwards from the edge of it, as from *a* to *b*, upon each side, a sod of 15 in. broad at top; and placing his line to the same measurements, he edges off with his spade, which should be an old half-worn one, kept rather sharp, a line of turf 15 in. broad, extending along the whole length of his first line on each side of the stance. It should be here observed that, in edging off these turf-sods upon each side, the operator must cut them with his face to the stance of the dyke, in order to make the outer edges of the turf slope contrary to the inner edges, as shown in the figure at *b b*; consequently the two sods of turf when cut, turned upside down, and laid along the side of each other upon the foundation, will appear thus . This answers a twofold purpose as the work proceeds; for the turf-sods are at once prepared to answer the sloping of the dyke as it progresses upwards; and as the turfs, in the case of joining them in the centre of the structure, are much improved by having a portion of earth put between the seams, this can at once be done by filling up the opening caused by the contrary slopes meeting in the centre. This opening is at once readily filled from paring the lower sides of the sods when lying as turned up out of the earth, and levelling them for another layer of turf coming above progressively.

When the two lines of turf have been formed by edging them off with an old sharp spade as directed above, a second man follows with the **turf-spade** (Fig. 150), with which he cuts the turf-line, now formed by the man before him, right across, into convenient lengths of about 18 in.; and as he cuts the turf into those lengths, *proceeding backwards*, he by a jerk of the implement turns each sod, as it is formed, with its grass side uppermost. Each sod, as it is thus turned up, is laid hold of by a third man, who places it upon its bed in the forming of the dyke, care always being taken to lay the first course of turf 3 in. within the outer edge *a*, on each side, which is meant to form the margin, in order to support the dyke the more firmly. When the three workmen have got the first course of turf-sods laid on the stance, they all proceed to have them properly placed, joined in the seams, levelled, and made firm and secure. And in the same

Fig. 150.



manner they continue throughout, one man edging off the turf-sods with a line to an exact measurement corresponding to the width of the dyke as it advances, so that each succeeding layer of turf, as it is laid on above the other, will be proportionally narrower than that just under it; whilst the second man cuts the turf across into convenient lengths, and heaves the sods up for his neighbour to lay hold of them the more readily and put them into their proper place in the dyke. As represented in the figure, the turf-dyke is built of sods taken equally from each side; and this is necessary both in order to save time, and to ensure that an equal proportion of the surface should be lifted from each side, so as to avoid tending to make the one field poorer than the other, as would be the case were the turf taken all from one side.

The thickness of the turf-sods must in all cases be determined by the nature of the soil. If the soil which forms the turf be light and sandy, the less of such material that is taken up the better, as it is extremely apt to moulder down quickly. Hence in a light sandy soil the turf-sods should not be pared thicker than 3 in.; but if the soil be heavy, a thickness of 4 or 5 in. may be taken. A good general rule for guidance in this matter is not to take the turf thicker than appears to contain plenty of the fibrous roots of the grass in it.

It will be observed from the figure that the first four layers of the turf are double, or consisting of two sods in one breadth. This is in order to obviate such a great breadth of the under sods as would render the work difficult were the turf put on whole. A good practical rule in this case is to make the under half double sods and the upper half single sods; and in all cases it is best to put on the upper turf with the grassy side upwards.

These turf-dykes are generally made about 36 in. broad at the bottom, and tapering regularly upon each side to about 14 in. at the top.

In the erecting of all turf-dykes, it is of the greatest importance to their future utility as fences to build them at the offset a few inches higher than it is ultimately intended they shall be; because in almost all cases they subside a few inches shortly after being put up. This is the more necessary to be kept in view where the soil or turf of which the fence is built is of a mossy or soft nature; and as this lesson is the result of long practical experience, it may well be borne in mind, in order to guard against mistakes arising from the inevitable shrinkage which takes place when the turf-sods settle themselves down. In order to make provision against too much subsidence, the following hints are thrown out. Where the natural surface consists of very rank growths of grass or weeds of any sort, the soil-covering should be removed as bare as possible with a scythe previous to cutting the

turf; and in the building of the dyke, if the turf-sods are damp and spongy, it should be made at least 9 in. higher than it is ultimately wished to be. That is to say, if a turf-fence of 30 in. be desired ultimately, it should in the first instance be made up to 39 or 40 in.; but if the turf used be from a moderately firm, loamy soil, 3 in. may be quite enough to allow for subsidence. Where it is intended to have a paling-fence upon the top, as is always necessary unless the dyke be made very high, a paling of this kind should not be put up until the fence has subsided fairly, else it would fall considerably under the paling afterwards.

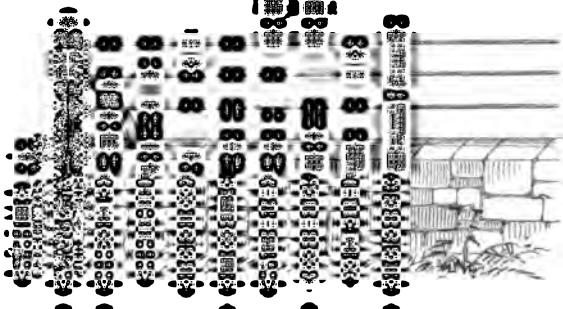
In all cases of erecting such turf-dykes, it is absolutely necessary to place a low wire-fence or a two-barred paling on the top (see Fig. 149, *c*), in order to prevent sheep or cattle of any description from getting over into a plantation or adjoining field. If the fence is placed upon the edge of a wood, and meant to protect it only, the paling may be put up as represented in Fig. 149 at *d*; but if it is put up for the purpose of dividing two fields, then the paling must be put up as represented in the same figure at *c*.

Turf-fences, from their being in all cases of a temporary nature, should not be erected where stones can be conveniently got for making stone-dykes, as the latter kind of fence is in all respects preferable. The only case where the former are at all recommendable is on high-lying moorland parts of the country, where stones cannot be conveniently had at a moderate expense for the building of stone dykes, and where a wire-fence alone is objectionable, on account of its furnishing no shelter to stock. In the sheep-grazing districts of the West of Scotland, turf-fences of the class described in the foregoing are extensively used for subdivision, as they are both cheaply erected and produce a considerable degree of shelter to the stock.

Stone Walls Topped with Wire.—A stone wall topped with wire forms a very useful fence, which is now frequently used in hilly districts where the particular object in view is to keep back sheep, &c., and which is even more suitable for that purpose than the turf-fence just described. In hilly districts, although a good stone wall be erected, light sheep will frequently get over it, and be the cause of much trouble and annoyance. In a case of this kind it is better to erect a dry-stone dyke with lime coping similar to those already referred to, though with this difference, that a projecting cope-stone is not required; but in its place a low wire-fence is used, which proves very effective in preventing any sheep from getting over.

The wall in this case is built quite in the same way as the common dry-stone wall, only that it does not require to be more than 4 ft. in height. The stones on the top are firmly put together and bedded in lime, and at every 9 ft. there is a good-sized through-

in the standards of the
ut in at about 9 ft. apart,
should stand 2 ft. high
made 1¼ in. broad by ½
at every 100 yards in
in. on the side of the
ood heavy through-band
e wires, and when com-



ription of fence, and will
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e formed by putting high
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s as to the manner of

Having fixed upon the exact line upon which a wooden paling is to be erected, ascertain the height that will be necessary for the purpose in view; and having decided upon this—say a four-barred paling—then in this case the fence will require to be about 4 ft. high above the ground when finished. Next ascertain if the ground be of a hard or soft nature in the line to be erected. If soft, the posts for the paling will require to be put at least 2 ft. into the ground, in order to make them secure and firm in their place, and to resist the pressure of cattle; if hard, then 18 in. in the ground will be sufficient. Thus, if the ground be hard, and the height of the paling be 4 ft., fully 18 in. must be added for the necessary depth of the post in the ground, so that the total length of the posts would have to be 5½ ft.; therefore posts of that length would have to be brought forward and laid all along the line, laying down one post for every 4 ft. in length of the fence, which is quite sufficient. When all the posts are laid down as directed, the horizontal rails will also have to be laid down, beginning at the one end of the line, and laying down four bars together continuously to the other. In laying out the posts and rails, care should be taken to keep them a little to one side of the exact line of fence, in order that the men may not be continually interrupted during their work by these lying in their way, and also to avoid laying the rails down carelessly upon the top of the posts. Both should be laid so distinctly that the workmen can have it in their power to lay hold of either posts or rails without any confusion or unnecessary handling of the materials. The general size of posts used for this purpose is about 4 in. diameter, and they may be either round wood, halved, or quartered, as the size of the wood may answer in making them. The best sort of wood for posts which have to be driven into the ground, and which are continually exposed to the extremes of both wetness and dryness in the soil, is the Larch. The horizontal rails for paling are generally made 18 ft. in length. These are sometimes made of Larch, and sometimes of Spruce or Scots Pine. Larch is out of all question the best for this purpose, and is generally sawn to the size of 4 in. by 1 in. Spruce Fir is perhaps the next in quality for paling-rails, Scots Pine being inferior to it in durability.

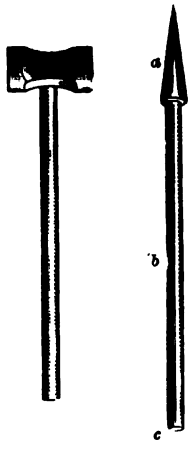
The posts and rails being all laid out as above described, the operator must next provide himself with a garden-line for stretching along the run of the fence, and a common nail-hammer, or what is termed a No. 3 paling-hammer, with claws for pulling out nails (Fig. 152). He will also require a bag for holding the nails, instead of having them lying scattered about, as with many careless workmen. This bag may be of leather or of coarse sailcloth, as may be most convenient; and as there are two sizes of nails used in the

putting up of palings, the bag ought be divided into two compartments, by being simply sewed up the middle. Another important tool in the operation of fencing is what is commonly termed the **post-mallet**. Many use for this purpose merely a block of ash-wood about 10 in. long and 6 in. in diameter, having of course a handle to it; but a mallet of this description never answers well, nor can a workman do much execution with it. The mallet ought to be all made of iron, and may be about 12 lbs. in weight. Fig. 153 represents such an iron post-mallet; in the hands of an expert workman it is a powerful implement.

Fig. 152.

If the ground be very hard and difficult to drive the posts into, it will be necessary to use a **borer** (Fig. 154), not only on account of the loss of time that would be occasioned by having the men toiling and beating upon a post for some minutes before they could get it to the desired depth into the ground, but also in order to prevent waste of the posts. This borer consists of a heavy piece of iron, *a*, which is pointed, round, and hollow in the centre, in order to receive the handle *b*. This pointed piece of iron, or **shod**, as it is termed by the workmen, may be made about 12 in. long, and about 3 in. in diameter at the top where the handle is inserted. The handle should be about 4 ft. long, in order that the operator may have the more leverage; and in making a hole for a post with it, it is forced into the ground by repeated strokes downwards from the workman, who holds it by the top, *c*, in his hands. It is found very powerful in making holes in hard ground. These implements, together with the nails, are all that are necessary for the putting up of a paling-fence.

Fig. 153. Fig. 154.



Where the soil is comparatively light, it is sufficient to have the posts well pointed, and to drive them home with a heavy iron-bound wooden mallet, or an iron sledge-hammer; but in order to avoid the splintering of the head, it must be protected with an iron-bound cap of some very tough wood like Hornbeam. Two men are of course requisite for driving home the fence-posts in this manner. Messrs Boulton & Park of Norwich manufacture an instrument (Fig. 155) for fixing wood posts for strained wire and wire-netting fences. This can be used either as a tree-planter (pitting instrument) or else as a **post-hole digger**, in the manner indicated in the illustration.

In commencing to put up the paling, the line should first be stretched along the run of the intended fence, and pinned down about 2 in. to the one side, in order that the posts may be put in the exact

e of wood should be cut of the
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hould be made with the borer for
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f it above with the stick for the
more handy, the height may be
allet and measured at once on the
ngths, it is best to lay a single
de of the line, allowing an over-
to proceed first to put in a post at
d to exact distances in this case.
pon having one post driven into
he ground at each joining of the
ails, the others must next be
rected between these, to as nearly
ft. as the spaces will permit.
After all the posts have been driven
in regularly as far as the line is
stretched, they should be examined
o see that they are regular both
on the top level and in a line upon
the side view. This can be readily
arranged by beating down one
where too high, or beating with the
mallet to a side any that may be
little out of the line. When the
posts are all regularly in and pro-
perly adjusted, two men take hold
of a rail and place it along the top,
so as to form the upper bar. Care
must be taken to have the end of
the rail commencing upon the first
post nearly on a line with the per-
e breadth of the post; whilst the
ould have it about 2 in. over the
ails it. This is in order to form
at that part; and in this position
re being taken to keep it rather
n lifting the second bar, which
er one, the man who is following
. behind the post upon which his
. In this manner the two men
top bar along the whole length of
same way return with the second

bar, which should be about 9 or 10 in. under the upper or first one. In putting on the second, third, and fourth bars, it is not so necessary to have the joints of these made upon the posts as directed for the upper bar. They may be joined in the middle, or where it may chance to happen, according to different lengths of the rails; because the three under bars are not likely to require to have so much strength as the upper one, which is always pressed upon by cattle, &c. The second bar being nailed on, the third one should be put on about 7 in. under it, and the fourth or under one about 6 in. under the third. The reason of thus making the bars closer as they come down upon the posts, is in order the more readily to keep back sheep or lambs, seeing that those spaces are on a level with their bodies.

In the same manner the whole of the length of the fence is put up, one line-length after another. Proceeding thus, two active expert men will put up from 25 to 30 roods in one day, where the soil is moderately soft.

In erecting wooden palings, it will not always be found that four bars will answer every purpose; for where cattle, sheep, and lambs are grazing, five bars will often be found necessary to keep them all in. Again, it may often happen that where there is a height upon the line of the ground upon which the fence is to be run, three bars may in such a situation prove as effectual a fence as four or five in other situations.

There is another description of horizontal paling excellently adapted for protecting plantations and subdividing fields, of which a large extent is now erected in various parts of the country. It is of a very much stronger character than that already described, and forms a more permanent and reliable fence where heavy cattle and horses have to be kept out. This paling consists of posts put into the line of fence at 9 ft. apart, with four or five horizontal bars fixed between each pair; and the usual height over all is 4 ft., measuring from the land-level. The posts are made from good and matured Larch or Pine timber, 6 ft. long, and sawn to a scantling of 7 by 3 in. The rails are also made from matured timber, 10 ft. long, 5 in. broad, and 1½ in. thick. The posts are mortised to receive the rails, as no nails are used in the erection of this sort of paling. The mortises are made right through the thickness of the posts, and are of dimensions suited to the breadth and thickness of the rails which they are intended to receive, 5 in. by 1½ in. In order to make the fence proof against small sheep or lambs, the mortises are so arranged in the posts as to have the lower bars closer to one another than the upper bars, as exhibited in the following illustration (Fig. 156).

ed into the ground is 24 in. in
evel and the opening or mortise
mortises 1 and 2 is 6 in.; that
7 in.; that between the mortises
permost mortise there is 5 in. of
ain sufficient strength to prevent
ade, or in driving home the bars.

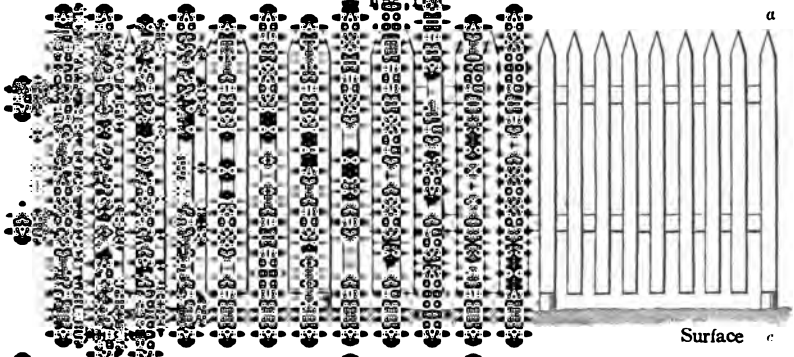
g in the uprights, the head of each
und cap which just fits over it, and
kes of the mallet.

e made to overlap properly and
inserted into the mortises, a slice
ed from each end of every one
by means of a sharp **adze**. In
the slices from the ends of the
is done obliquely all from one side;
hen any two ends are put into a
t is only necessary to place the
e of each, the one to the other,
to have a complete junction and
ous line of rail. This oblique
ining may be from 4 to 6 in. long.
sort of fence is usually erected
lowing manner. The timber, pre-
the manner specified, should be
n along the line of posts and rails
ular and systematic way before
ing to erect the fence; and while
eing done, the holes or pits should
at exactly 9 ft. apart to receive
. In erecting the fence, after the
has been fixed in its place, the
he four bars are at once put into
must be made firm in its place by
two are placed one on each side of
r two, one on each side of the post
firmly between the posts and the
s is being done by two men, other
ged in putting the second post into
o fix it, they place the other ends
d into the first post, into the corre-
hich they stand; and immediately
the second post, while the two

[illegible] the third one; and so [illegible] to the last post before [illegible] way any length of the [illegible] the Highlands of Scot- [illegible] have lasted upwards of [illegible] made of good timber.

[illegible] horizontal palings which [illegible] nt and generally useful [illegible] heights in order to suit [illegible] ly to give an example [illegible]; for, by referring to [illegible] erection will be readily [illegible]

[illegible] made of Larch-wood. [illegible] be either sawn timber,



[illegible] 3 in. in diameter, and [illegible] ose, for example, that a [illegible] d that it is to be 5 ft. [illegible] place, been brought for- [illegible] the run of the intended [illegible] the ground in the same [illegible] horizontal fence, all at a [illegible] supposing that the tops [illegible] e height of the uprights, [illegible] quire to be 4 ft. high [illegible] been put in along the [illegible] levelled along the tops, [illegible] with the nature of the [illegible] n having the upper rail [illegible] e posts, care being taken [illegible] ne manner as formerly

recommended. When all the upper rail has been fixed, the second of the two horizontal bars requisite in the spar-fence must be nailed on and joined upon the posts in the same manner at about 16 in. above the surface of the ground, or 2 ft. under the upper horizontal bar. In putting on the upright spars upon the framework now formed by the posts and the two horizontal rails, a commencement should be made by nailing on one of the spars at the extreme end, care being taken to keep the top of this upright 12 in. above the upper rail *b*, to place it at the same time so as to cover the post forming the extreme end, as at *c*, and to allow the latter to appear at the bottom only. And in the same way an upright is fixed upon the face of every third post for the whole length of the line of posts, exactness being secured by measuring the top of each to 12 in. above the upper bar; and when this has been done, a nail should be put into the top of each of these uprights, but driven only so far into the wood as not to be taken out easily without the aid of the hammer. After a nail has been put into the top of each, the line should be tied to the nail upon the extreme end, and should be carried along in the hand, making one turn of it round each nail as it is passed, and keeping the line tight all the time. When the line has been stretched tightly along the tops of the spars by means of fixing it round the nails, it will now act as an easy top-guide for putting on all the rest of the spars between the nails to their proper height. As the fence is 5 ft. high, the uprights will require to be only 4 ft. 9 in. in length, for they should be kept about 3 in. up off the ground or surface, as seen in the figure. In putting on the spars, no particular attention need be paid to their regularity at the base, though most particular care should be given to the arrangement of the spars at the top, as they catch the eye more there. But in nailing the spars on, care should of course be taken to have them put on as nearly perpendicular as possible, and keeping from 2 to 3 in. of open space between each two. An endeavour should always be made to have an upright fixed so as to cover and hide each post from the view; and this can be done by a little attention in regulating them. A fence of this description should always have the spars nailed upon that side which is to be most seen; consequently this point should always be taken into consideration before commencing the work.

Erection of Wire-Fences.—In the matter of fencing, as well as in that of shipbuilding, this may be truly said to be the "iron age;" for wire-fences are now, generally speaking, setting aside most others, and taking their places. This is in consequence of the material of which these fences are made being cheaper than stone walls or dykes, more durable, more easily and rapidly erected, and often more ornamental than mere wooden fencing. As wire-fences are therefore of the

first importance in this branch of arboriculture, it will appear desirable to give a detailed description of the most practical methods of erecting them.

The editor would, however, here again intone the fact that such costly and unproductive boundaries as fences, however necessary they may in Britain be deemed for arboriculture, are in reality a hindrance to sylviculture. In Britain, fencing round plantations and woods is the rule; in the forests of the Continent it is the exception.

Wire-fences can, of course, give no shelter to land or stock, but are purely of use in keeping out cattle, sheep, and certain kinds of game.

Different Kinds of Wire-Fences.—There are three different classes of wire-fences in general use—I. those consisting of wire strained on wooden posts; II. those erected on iron straining-posts with intermediate wooden posts; and III. those erected entirely of iron and without any wood. But all these different kinds of wire-fences consist of four main parts—(1) the straining-pillars, (2) the standards or intermediates, (3) the stays or struts, and (4) the wires.

Fig. 158.

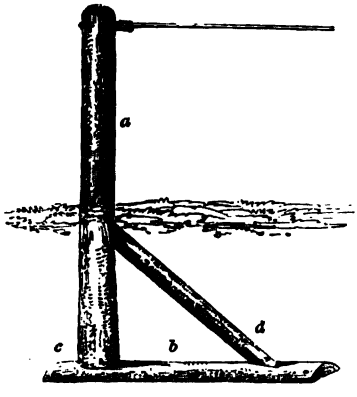
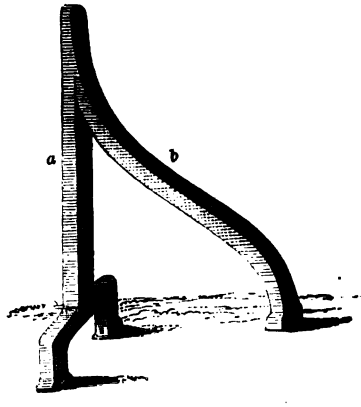


Fig. 159.



(1.) **Straining-Posts.**—The straining-pillars are for keeping the horizontal wires at full stretch, and may be of wood (as in Fig. 158), or of cast or wrought iron (as in Fig. 159), batted into large stones, wooden blocks, or cast-iron blocks, sunk and firmly fixed in the ground, and supported by stays. If the line of fence be straight, the straining-pillars are placed from 80 to 100 yards apart, and in some instances over 200 yards; but if the line be curved, intermediate straining-posts with stays are required.

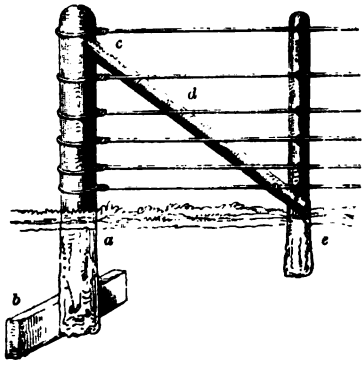
In Fig. 158 the wooden straining-post is shown with its sole and stay underground. The post (*a*) is 7 ft. long, and 6 to 7 in. in diameter at the upper end; it is pitted into the ground to a depth of 3 ft., and let into a sole (*b*, *c*) of 3 to 6 ft. long, 6 in. broad, and 3 or 4 in. thick; whilst additional

strength is given by means of a strut (*d*) nailed upon the sole, and notched and nailed into the upright post.

Another method of fixing the straining-posts is shown in Fig. 160, where the main post *a* is strengthened by a plank base *b*, and a strut *d*, which is nailed on to a standard *e*, and notched into the main post at *c*.

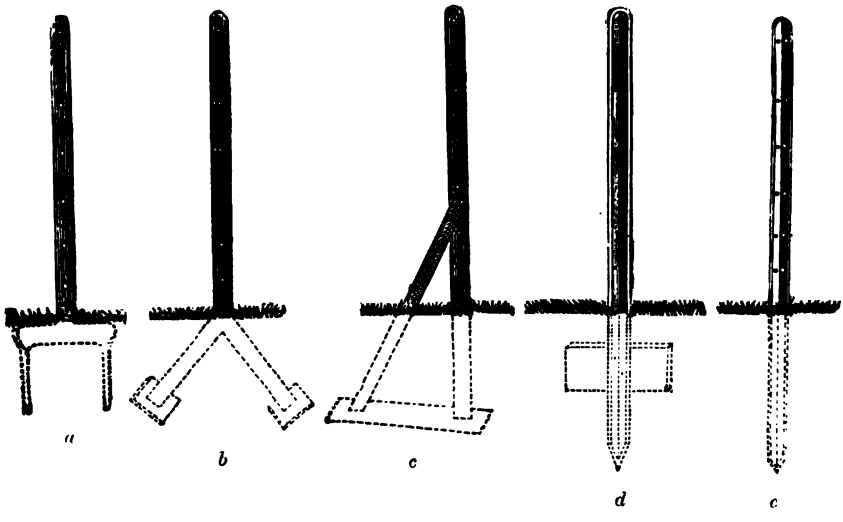
(2.) **Standards.**—The standards may be of wood or wrought-iron, and are placed from 3 to 9 feet apart, according to circumstances. They are absolutely necessary to keep the horizontal wires at regular distances apart, and to support the fence as a whole. Wooden standards are either driven into the ground or sunk into holes in the same way as the posts are in a paling-fence; but iron standards usually require to be either batted into stones or driven into sunk blocks of wood; they may, however, be "self-fixing," or fitted with feet at the base to admit of their being driven into the ground. Stays are necessary in most fences for the standards at all curves; but these are made much slighter than for straining-pillars.

Fig. 160.



When iron standards are used, the first cost is greater, but the outlay on maintenance and up-keep is practically *nil*. There are a great many

Fig. 161.



varieties, whose special details may easily be seen in the catalogues of firms like Messrs Bayliss, Jones, & Bayliss, Wolverhampton; Messrs Boulton &

Paul, Norwich; and Messrs A. & J. Main & Co., Glasgow. But the general principle of supporting and strengthening standards will easily be seen from Fig. 161.

(3.) **Stays or Struts.**—Stays (see Figs. 158, 159, and 160) may be of wood or wrought-iron, and are required to prevent the straining-pillars from being drawn off the perpendicular by the tension put upon the wires. Iron stays are made double for straining-pillars, and single for standards, and are batted into stones or driven into wooden blocks; or they may have flat blocks attached.

(4.) **Wires.**—The wires are placed parallel, and at suitable distances from each other. They are passed through holes bored in the iron standards, or are fixed with staples to the wooden ones, and are kept at a proper tension by the straining-pillars. To a person not familiar with the usages of trade, there is often a difficulty experienced in choosing the proper kind of wire. There are two processes of making wire—**rolling** and **drawing**. The former is the cheaper method of manufacture; because an inferior quality of metal can be used in it as compared with the latter, which is a more tedious process, involving a greater strain on the metal. In purchasing wire, the best kind can always be known from its being in long lengths, while the inferior quality is in comparatively short lengths. Of course, wire in short lengths can always be bought at a cheaper rate than in long lengths; but, when wire of good quality is wanted, a fair price should be given for it, in order to have it of long lengths. In erecting wire-fences, it is of great importance to have them made of the best kinds of wire. Although it may cost more at the time, yet it will certainly be found much cheaper in the end, as the workmen's time lost over an inferior quality of wire is frequently of more value than the wire itself.

Wire for fences is sold under the following names:—

1. **Bright Wire.**—This quality is what is called **cold drawn**, and is very hard. If the fence is to be rendered elastic, and capable of resisting pressure without yielding, this kind should be preferred. It is difficult to knot; hence it is only to be recommended when experienced workmen are employed in the erection of the fence.

2. **Annealed Wire.**—This quality is also cold drawn, but is afterwards annealed, whereby it is softened, and therefore rendered more pliable and easier to knot; it can therefore be more easily used by inexperienced workmen.

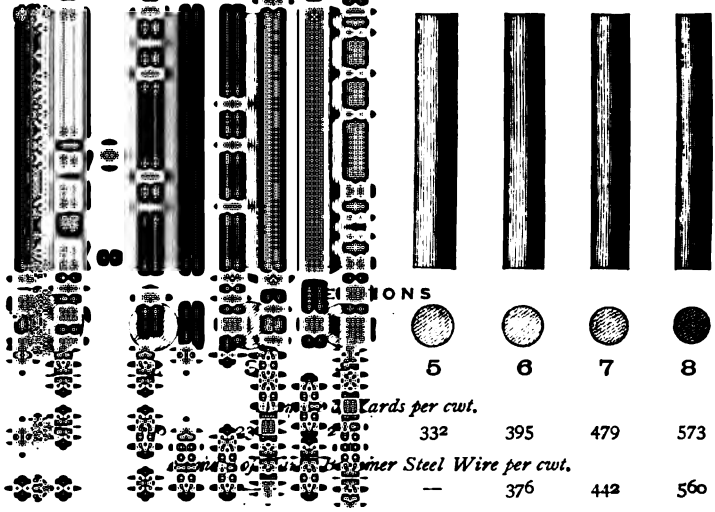
3. **Black Wire.**—This quality is rolled, and is not sold in such long lengths as the preceding. It is soft, and not elastic; but it knots easily, and is therefore well adapted for ordinary purposes where cheapness is a consideration.

4. **Galvanised Wire.**—This is the annealed drawn wire galvanised. The advantage of this kind is its freedom from rust, indepen-

[illegible] process of galvanising renders it more [illegible]

[illegible] this description of wire can be had [illegible]

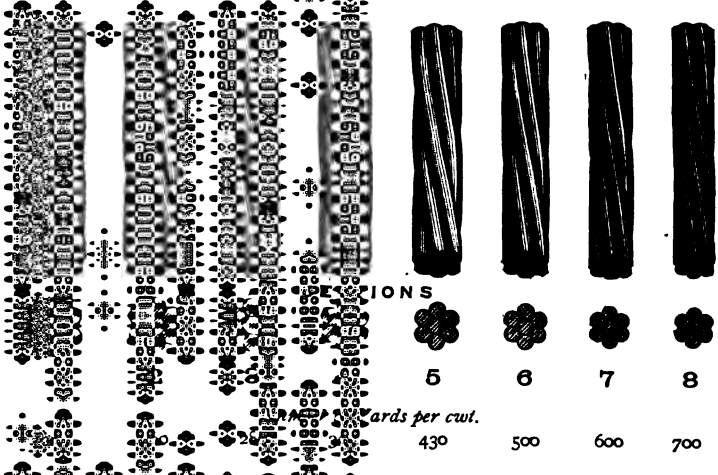
FIG. 162.



[illegible] higher strain than iron wire, can be [illegible] without breaking.

[illegible] wire used in fencing, each thick-

FIG. 163.

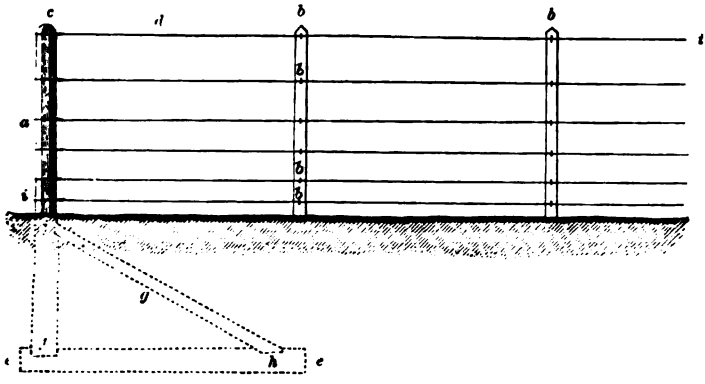


[illegible] number, so that when any particular [illegible] to by its distinguishing number.

Fig. 162 shows the exact size of each kind of wire sold, together with their numbers, and to each is added the distance to which 1 cwt. will usually run.

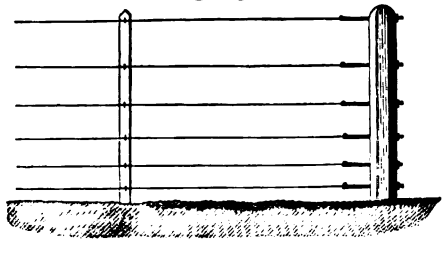
Besides the solid kinds of wire just referred to, there is also the **Galvanised Strand or Rope Wire.** It is composed of seven or of three small galvanised wires or strands, twisted together like a hempen

Fig. 164.



rope. It bears a much greater strain than solid wire, and contains a greater number of yards to the cwt. than the corresponding numbers of solid wire. Of course, the seven-ply wire or strand is the strongest, and is now much in use in this country for general fencing purposes. It is soft and pliable, and is generally made in much longer lengths than the solid wires. Fig. 163 shows the various sizes of the seven-ply wire, together with the number of yards to the cwt. of each.

Fig. 165.



I. Wire-Fences Strained on Wooden Posts.—Figs. 164 and 165 represent the extreme ends of a wire-fence upon wooden posts 3 ft. 9 in. high, and adapted to resist sheep and cattle.

The exact line for a wire-fence being fixed on, have the first **post or straining-pillar,** *a*, Fig. 164, made as there represented (see also Fig. 158). Have it made of the best Larch timber, taken from a full-grown tree, the wood of which may be considered matured and full of resin, and not of the wood of a young tree, as is too often done; for, although apparently as good, timber of the latter class will not endure nearly so long as the well-matured wood of a full-grown tree.

The wire-fence, as here represented, is in general made 3 ft. 9 in. high from the surface of the ground to the top wire *d*. Consequently the post *a*, which should be sunk 3 ft. 6 in. into the ground, will require to be made 7 ft. 6 in. long, allowing 3 in. for the round upon the top above the level of the upper wire, as at *c*; and if it is to be made octagonal in shape, as is generally the case, it will require to be of at least 8 in. in diameter. In preparing the straining-post, it adds to its strength as well as its durability not to take any of the outer wood off the part which is to be sunk in the ground; for the more bulky that part is, so much the greater, in every respect, will be the stability of the post. In dressing the straining-post, therefore, only trim the part which is to remain above ground. When ½-in. holes have been bored through the post at proper distances for the reception of the wires, as shown in the figure, another piece of Larch should be prepared, 6 ft. long by 8 in. by 6 in., to act as a sole for the post to rest upon in the ground, as indicated by the dotted lines at *e*, *e*, in Fig. 164, and by *b*, *c*, in Fig. 158. In this sole a part upon the broadest side must be cut out, about 2½ in. deep, across the whole breadth of the wood, and large enough to hold the bottom of the post in it, as at *f*, care being taken to leave about 6 in. upon the end for a heel; into this groove the lower end of the post is fixed, and its firmness secured by means of two very large nails driven through the post into the sole. When this has been done, another piece of Larch-wood, *g*, is taken of such length that one end may be fixed in a groove to be made near the point of the sole, as at *h*, whilst the other end rests in another groove, to be notched into the post to a depth of 1 in., as at *i*. This piece of wood, which should be about 7 in. by 4 in., is called the underground stay or strut, and is meant to act as a support against the strain of the wire; while, at the same time, as it is not seen above ground, it consequently does not interfere with the light and neat appearance of the fence when finished.

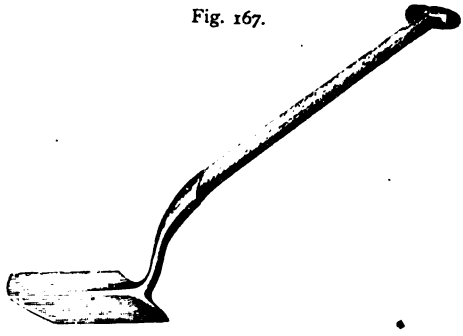
The first straining-post having been completed in the manner stated, the next step in the work is to have a pit dug in the ground for its reception, making the one end of it exactly where the fence is meant to begin, and extending it to a depth of about 3 ft. in the direction of the line of fence, so far as to hold the sole when put in. In making these pits for the reception of the posts, the ground is in almost all cases found so hard as to require picking, at least in the under half; and as it is necessary to make the pits as near the exact dimensions of the wood to be put in as possible, in order to have the more solid ground about the posts, it is often a work of considerable difficulty to form them without proper implements. The implements most suitable in the making of pits for wire-fence posts, as also for gate-posts in general, are the common garden-spade, for digging off

the surface turf and upper soil, and the **foot-pick** (Fig. 166), which is preferable to the common hand-pick. As there is not sufficient room for a man to use the hand-pick with advantage in the making of such pits, in all cases of this nature the foot-pick should be used; it is a most efficient instrument, and enables a man with great ease to loosen the hardest subsoil or stones in the opening out of the pit. The **horizontal spade** (Fig. 167), is also a very useful implement when removing soil from within 18 in. under the surface; it has a handle about 2 ft. long. With it a man can work with great freedom in the pit, where he is much confined for want of room; and by means of it he can in such cases do more than double the work he could accomplish with the common spade.

When the pit has been made and properly levelled at the base, the straining-post is put into its place, in such manner as to keep

Fig. 166.

Fig. 167.



it perfectly upright. This can readily be done by the aid of the **plumb-line**. When the post is placed upright, two wedge-shaped pieces of Larch-wood, about 18 in. long, and having the form of the pointed end of a strong post, should be beat obliquely one into each end of the pit, as at *e*, *e*, in Fig. 164, between the solid earth and each end of the sole. This is meant to secure the stability of the sole in its place, and consequently the pegs ought to be well driven home. The earth which comes out of the pit should now be broken down, and gradually filled into it again. In this re-filling, not more than 3 in. of the loose soil should be put into the pit at once, without having it properly beaten down solidly with **a rammer**, or a piece of wood in the shape of a common post, and about 4½ ft. long, which is shod with a piece of iron upon the under end in order to make it heavier and more effective. This laying in of 3 in. of loose

earth, and then beating it home with the rammer, should take place alternately, until the hole is filled, and the post stands perfectly upright.

The next matter to be attended to is to see whether the ground upon the line of the proposed fence is level or uneven; for a great deal depends upon this, and the manner of going to work must be regulated accordingly. This may perhaps be more clearly illustrated by reference to Fig. 168, which is intended to represent a continuation of a line of wire-fence both upon level and upon even ground.

Here it is supposed that the first straining-post, *a*, in Fig. 164, is represented by the post *a* in Fig. 168, and is now properly secured in the ground as above described. And supposing further that the ground from the post *a* to the post *c*, which is perfectly level, is about 160 yards in length; it is evident that this space is too great to be properly tightened up between the two posts *a* and *c*; therefore another post must be erected between them, as at *b*. It ought also to be observed here that in all cases of putting up wire-fences on wooden straining-posts, they should never be much more than 80

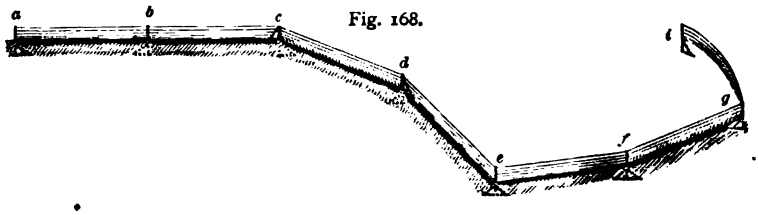


Fig. 168.

yards distant as a rule, and in no case more than 100 yards apart. If they are much wider, the proper tension of the wire cannot be attained so as to make a secure fence. In the present case, therefore the next step in the progress of the work would be to put up another post at *b*, about half-way between *a* and *c*. This post is erected in exactly the same manner as the first one, except that the underground stay of the second post should be put in in such a position as to resist the strain of the wire from the post *a*. This is effected by placing the stay the reverse way from that adopted in the case of the first post; as represented in Fig. 168 at *b*, the stay upon the post there does not lie in the same direction as at the post *a*, but faces the opposite direction. Thus each pair of posts is complete in themselves, and independent of one another, which is the object desired. The second post being secured, the next thing to do is to have the intermediate uprights or standards erected, as represented in Fig. 164 at *b*, *b*. These should be of the best Larch-wood, 6 ft. long, and 4½ in. by 3 in. Before putting them into the run of the fence, one line

should be stretched tightly between the bases of the two straining-posts upon the surface of the ground, and another between the tops, or in the exact position of the intended top wire, running each end of it through the upper hole in each post; and when both of these lines have been stretched as a guide for top and bottom, the intermediate uprights should be put in at 5 ft. apart, upon the opposite side of the line that it is intended the wire should be put on; or, in other words, care must be taken that the hempen line is in the exact place where it is intended the upper wire shall be. Another point necessary to be considered at this stage of the work is that the wires should be put upon that side of the posts where it is known there will be most necessity for strength on the part of the fence; for if heavy cattle be upon the opposite side of the wires, they are very apt to press out the staples which hold the wires to the wood, whereas upon the other side they can have no effect whatever upon its stability.

With regard to the method of putting the intermediate uprights or posts into the ground, some make holes for them with the spade, while others drive them into the ground by the paling-mallet; but Messrs Boulton & Paul's post-hole digger (Fig. 155) seems a very handy instrument for hollowing out holes to the requisite size without loosening the soil to a greater extent then is actually necessary.

The best method to be adopted in fixing the standard-posts depends, however, to a very great extent upon the nature of the soil along the line of the fence. In many cases it is almost impossible to get a post driven into the ground, owing to the quantities of small and large boulder-stones that are in it; hence sometimes one method is preferable, and sometimes the other. But the nature of the soil, and the circumstances of each special case, must form the sole guide in this matter.

When the posts are being driven into the ground with the mallet, an iron cap is fixed over their heads not to let them splinter and spoil; this cap is the exact shape of the top of the posts, 4½ in. by 3 in. inside measure, so that it fits exactly, and indeed rather tightly upon them (Fig. 169). In driving home the posts, one man lays hold of the top of each post with this implement; and by its use the posts are not damaged on the top by the action of the mallet. The man holding them thus at the top has at the same time a great power over the posts, and can turn them at will if they happen not to go in right; it is therefore called the **post-guide**.

Fig. 169.

As previously remarked, an iron-bound cap is often used instead of this implement; and it seems well deserving of further use, for then the tops of the posts are not frayed or damaged in any way.

The posts having been put in at 5 ft. apart along the whole length of the line between the two first straining-posts, very exactly with the run of the line both at bottom and top, and 3 in. of the top of each upright being left above the line or run of the upper wire, in order to strengthen the fixture of the wire at top (as in Fig. 164, where it will be seen that the top of each post is a little above the top wire), the next step is to have the wire prepared or drawn for putting on between the two straining-posts. The wire, as it comes from the manufacturers, is in general rolled up into bundles, each containing from 40 to 80 or 100 yards in length, and often much longer. If common wire be used, it keeps its circular form in these bundles, and consequently a wire-straightening machine is required, such as is represented in Fig. 170. In using this the wire is pulled through between the two sets of wheels, and is afterwards found straight and ready for use. Some of the better kinds of wire, however, uncoil perfectly straight, and in that case the wire-straightener is not required. Having straightened about six lengths of the wire to be used, and laid them down between the two straining pillars, the next thing will be to have them fixed. Before taking down the line which was stretched between the tops of the two straining-pillars for the purpose of regulating the tops of the uprights, and which, of course, will be in the exact place where the top wire of the fence is intended to be, it should be stretched very tightly; and when it is properly tightened and taut, the exact track of the line along the top of the posts should be marked off with a carpenter's pencil, after which the line may be taken down. On its being removed, staples should be taken to hand for nailing the wire to the posts. These staples are made of the same material as the wire itself, and are of different sizes; but those made $1\frac{3}{4}$ in. long are perhaps the best for general use (Fig. 171).

Fig. 170.

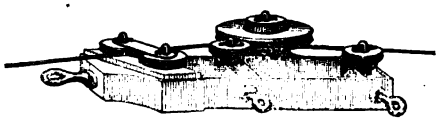
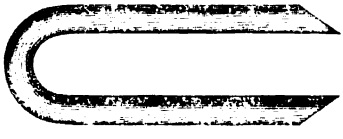


Fig. 171.



One of these staples should be driven into each post at the mark made by the pencil, and right in the middle of the wood; and when they have been driven in about half length all along, the upper wire may be run through the upper hole of the first pillar, and through each of the staples in the posts. One end of the wire is fastened to the post *a* (Fig. 164) by being brought half round it, and twisted by means of the turn-key (Fig. 172) round the wire inside of the pillar

as the next straining-
of the same description,

Fig. 172.

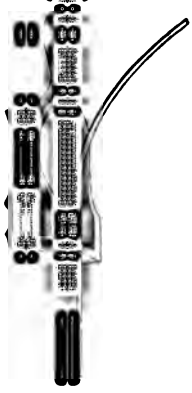


Fig. 173.

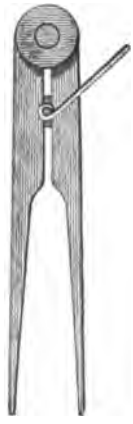


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Fig. 174.

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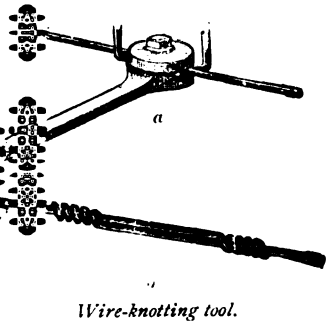
Fig. 175.



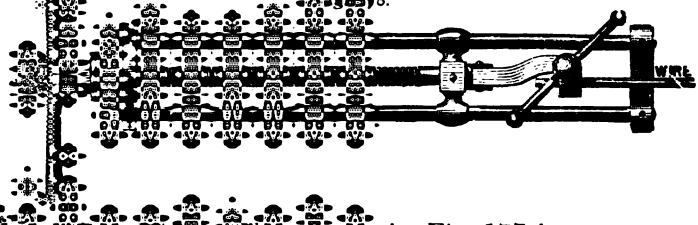
Wire-knotting tool.

wire is properly strained,
o have the wire brought
e is required, of which

he common straining-screw (Fig. eans of a jointed vice, as at *a*, pure by means of a screw and can be made to hold as tightly as if it were all a solid piece. The wire being passed through the upper hole of the post, as already directed, it is taken hold of by opening the vice at *a* and screwing it tight upon the end of the wire; but previous to doing this, ed by placing the saddle attached upon the post. This done, and the wire may be screwed up by desired tension is gained, which may be known from the wire in its whole length between the straining-posts being tight like a string upon a musical instrument. The wire which projects or hangs out behind the post is now taken half round the same manner as at the other can be removed. The top wire n the bottom one.

screws for wire-fences are shown

Fig. 178.



in Fig. 177 is extra strong. It what is conveyed in the illustra- a of the mode of working. It is of the machine at *a* being placed through the opening there, and

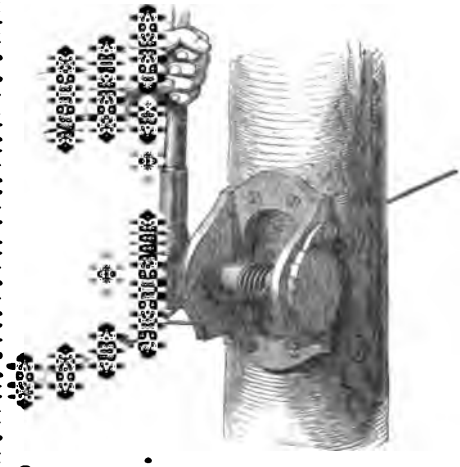
and nut, after which it the wire can be keyed That at Fig. 178, the pieces, and has a power- wire in one length. It

Fig. 179.

s, & Bayliss of Wolver-

ng the wire round the bed, **screwed eye-bolts** re (Fig. 179). The wire one end, as seen in the le in the post, a **nut** and post. The wire is easily

Fig. 180.



should not be less than made 15 in. in length. ich is intended to show ans of them. Figs. 164 ence, where the wires in Fig. 165 are secured by

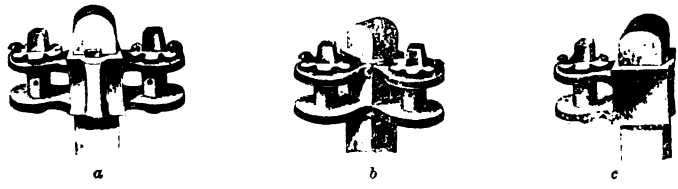
iner for wire-fences on

wooden straining-posts. It is more effective than the screwed eye-bolts, and is very simple in construction. The figure will at once show for itself how it is worked, which is simply by attaching the winder to the post with screw-nails, so that the wire coming through the hole in the post can be wound round the crank, and strained up by turning the key as shown in the figure. They also possess the advantage of enabling a man to tighten the wires at any time when they require it. Of course one of these winders is required for each wire, and remains on the fence for use at any future time.

Another form of winding-bracket, manufactured by Messrs A. & J. Main & Co., Glasgow, and adapted for square wooden posts, is exhibited in Fig. 181, showing respectively posts *a* in the line of fence, *b* at an angle, and *c* at an end. The illustrations require no description, as the power is applied by means of a straining-key as shown in Fig. 180.

In the same manner as has been detailed for the putting on of the upper wire of a wire-fence, all the others are also fixed, care being in all cases taken to keep the distance between the wires closer near

Fig. 181.



the bottom than at the top. In general, where sheep or lambs are concerned, the distance between the two lower wires should be 5 in., which may be increased gradually to 10 in. between the two uppermost wires.

Fences of this description can be made of any convenient height to suit the purpose for which they are required. For deer they are usually made 6 ft. high, so as to have ten wires in depth, instead of six, as is generally allowed for sheep and cattle. Fences for deer, however, are now usually made of iron, which is found more suitable. However high these fences may be erected, the work is all done upon the same principle, save with this difference, that in erecting a wire-fence above 4 ft., it is always necessary to have an iron stay put to the straining-posts above ground, as well as a wooden one underneath, in order to secure them more perfectly against the strain of the wire. These stays are sunk into stones, and batted with lead or cement; and the stone for one of such stays ought not to be less than an 18 in. cube, sunk about 3 in. under the surface.

The higher the fence, the deeper also ought the post to be sunk

in the ground. In erecting a fence of this description 6 ft. high, the sole of the ground stay would require to be 4 ft. under the surface. The staples should never be driven home in the uprights; but there should be room left for the wire to move through them, else the strainer will not have the effect of tightening the wires whenever this is found necessary. As soon as a wire-fence has been completed, the posts, if made of properly seasoned wood, should be painted with black varnish, or should receive a coat of coal-tar, and the wires may be coated over with common oil-paint; for, if it be allowed to remain any time without being painted, the wire will soon become rusted, and will be apt to break if weakened by being corroded.

What has been said above relative to the putting up of wire-fences of this kind is only applicable to a length between two straining-posts, and upon level ground; but in order to make this branch of fencing more completely understood, the observations must be continued a little further. When reference was last made to Fig. 168, it was said that from the post *a* to the post *c* was all level ground, being 160 yards in length. To the half of this space, or from *a* to *b*, the above details of the manner of erecting the wire-fence apply. But the mode of procedure regulating the erection of the other stretch, from *b* to *d*, will vary from the description already given. In this part it must be observed that the posts *c* and *d* are erected upon points from which the ground falls away suddenly; and in this case it is necessary to have either double wooden stays under ground, as shown at *e* and *f*, or an iron stay to each above ground, upon the sides of the posts opposite to those upon which the underground wooden stays are. The reason for having such extra stays at these two posts is that, supposing the wire to be suddenly broken between *c* and *d*, the great strain acting upon these two posts, from *a* on the one hand and from *e* on the other, would very likely pull them suddenly backwards, and disarrange a considerable extent of the fence. Now, the simple precaution of having another stay put up at each, prevents this from taking place under any ordinary circumstances; but in every other respect the wire-fence is erected in the same manner as has already been detailed. In all hollow portions of the ground upon which a wire-fence is erected, the posts at such parts should be sunk deeper than upon level or prominent parts; and the soles used there should also be much heavier than those commonly employed, and with heavy ground stays, one on each side of the post, as shown at *e* and *f*. For were these posts erected in a manner which might answer perfectly well at *c* or *d*, the great strain of the wire upon each side of them would not only endanger their security as a permanent fence, but it would be apt to draw them entirely out of the ground, as sometimes happens. On a little reflection, it will

appear evident that the strain of the wire at *c* and *d* tends to press the posts downwards into the earth, but at *e* and *f*, on the contrary, it tends to lift them out; and this at once shows the necessity there is for attending to this point very carefully.

Supposing that the fence has been completed as far as the post *g*, at which it makes a bend. Now, all the difference in erecting a wire-fence upon a bend from erecting it upon a straight line is that the posts forming the angles of the bend *g* to *i* require to have an extra stay above ground upon the inside of the curve; and every intermediate upright must also have a stay either under or above ground, in order to resist the pressure of the strain inwards. But if the curve be moderate, a stay at each second or third upright may be quite sufficient. In all cases where a gate occurs in the line of a wire-fence, that should be made to have the same appearance as the fence itself, by putting in the same number of horizontal wires in it that there are in the fence.

With regard to the cost of erecting wire-fences upon wooden posts, of course the price must in all cases vary according to the strength of the wire used, as well as in proportion to the height of the fence to be erected. As has been already stated, there are different sorts of wire used in the erection of those fences, which are known according to their respective numbers, as shown in Fig. 162. In putting up a fence, the kind of wire with which to erect it must in all cases be determined by local circumstances; for the heavier sorts should be used where there will be heavy pressure on them, whilst the lighter sorts may be employed where only sheep and small cattle are to be kept out.

The prices of the different sizes of wires can be had on application to any of the manufacturers of wire-fencing already named, together with estimates for the erection of the many various kinds of fences. Before any extensive work of this kind is entered upon, it is advisable to call for estimates for the supply of all the requisite materials. It must also be kept in view that the price of the wire is at all times regulated by the market-price of iron, which is subject to fluctuations; hence no details as to cost of ironwork need here be given.

The galvanised strand or rope-wire, as shown in Fig. 163, makes an excellent fence on wooden posts for either sheep or cattle, as it is tougher and stronger than the best solid wire; it may therefore be strongly recommended for use where a really efficient fence is wanted to resist heavy cattle, &c.

II. Wire-Fences erected on Iron Straining-Posts with Wooden Intermediates.—As so much has already been said in reference to the erection of wire-fences with posts entirely of wood, it is not necessary

that equally minute details should be given on the subject of putting up this new class of fence, as the only difference in dealing with it is the using of iron strainers instead of wooden posts. Under this head, therefore, the remarks will be confined chiefly to a description of the iron strainers in use and the mode of erecting them; for in all other respects the intermediate posts are similar to those already described with regard to the erection of the wire-fences entirely on wooden posts.

Fig. 182.

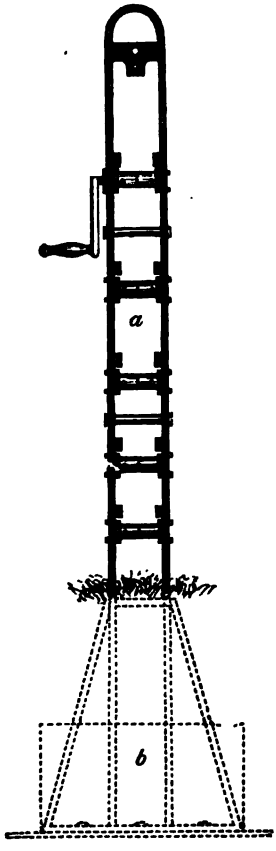
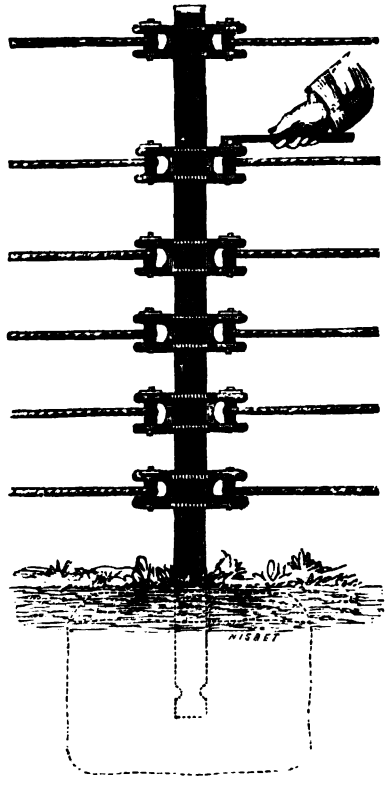


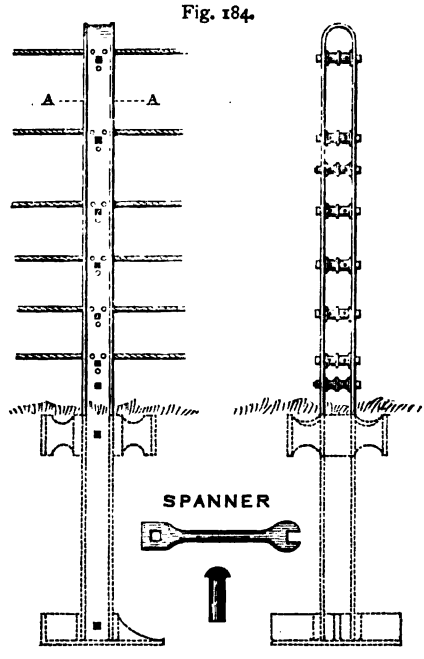
Fig. 183.



Iron straining-pillars are a great improvement in wire-fencing, not only because they are more permanent than wooden strainers, but also because the fence can be more easily and more neatly put up with them than with wooden posts, and more especially when those fitted with a winding apparatus are used. Figs. 182 and 183 show iron straining-pillars fitted with winding apparatus, and different kinds of handles for winding. Both descriptions of strainers are manufactured and sold by Messrs A. & J. Main & Co., of Glasgow,

London, and Dublin. They are made either with single or double winding action, as may be required for special purposes. Those shown in the figures are of double action—that is to say, the barrels *a* are all double, and therefore the wires can be strained from both sides by the same pillar; and by means of this double action half the number of strainers usually required is sufficient for the straining up of a fence, which forms an important saving in fencing by their use. One of these double-winders fixed at every stretch of 500 or 600 yards in the line of a fence is found quite sufficient for perfect tension; whereas one single winder would otherwise be required for every 200 yards. From the figures it will be seen that these strain-

Fig. 184.



ing-pillars are made with very large bases, *b*, which secure them firmly in the ground.

At the beginning or termination of a fence it is not necessary to use a pillar of double-winding action, but of single action only, as in such a position the winding is only necessary from one side. Therefore, in erecting fences with these winding-strainers, those having the double action are used only where the straining is required from both sides, while one with a single-straining action is used at the beginning and at the end of a wire-fence. Indeed, many use the double-action strainers only in the middle parts of a fence, with only a common iron post at beginning and ending, to which the wire is merely fixed in

the usual way; and for all practical purposes such a post answers perfectly well, as all the straining can be made from the second post from the end, which of course should be one of double action, fitted to draw up the wire from both sides when that is necessary. The erection of a wire-fence by means of these straining-pillars with winding apparatus is so extremely simple, that really little or no explanation is necessary beyond what has already been said. The pillar is securely fixed in the earth by means of its own attached iron base, and is supported against the strain from the next pillar by an iron stay, which has also an iron base attached to it. When once erected firmly in this way, the ends of the wires are next attached to the respective barrels, by being passed through the holes in them for the purpose, and are afterwards wound up to the desired tension by means of the handle.

Besides the foregoing description of double-action straining-pillars for wire-fencing, there are several others, now very much in use, from which a choice can be made. Fig. 184, for example, shows one of Bayliss's "Victoria" double-action pillars with its various parts. They are very strong; the frame is made of wrought-iron, and they will strain from 500 to 1000 yards. The double pillar, the principle of which is shown by the above figure, strains the wire on each side in the same horizontal line, either in a straight line or at an angle. The two rollers have a common spindle, and revolve independently of each other. Holes are bored in the side frames for the rollers to work in, and the rollers being placed between the two side frames, these are bolted together with distance pieces between, and the pillar is complete. The construction of the pillar is so simple that any labourer can erect the fence. The ends of the wires are passed through the hole in the roller, and when sufficiently strained, a pin is passed through one of the holes on the side to one corresponding in the flange of the roller, which is thereby securely held in position.

The principle of the single pillar, manufactured by the same firm, is shown in Fig. 185. Both these straining-pillars are excellently adapted for straining long lengths of wire-fence, are constructed of considerable strength, and possess the latest improvements. The figures speak for themselves, so that further explanations are unnecessary with regard to them.

There are other straining-pillars, of a very similar construction, which can be had from any of the fencing manufacturers; but these two varieties which have been specially mentioned are sufficient in order to show the principle upon which they all work. Their use does not add to the cost of the fence; but rather, from the greater length they strain, lessens the cost as compared with wooden strainers. It will be readily seen and understood that these double pillars do

not require any stays when the line of fence is straight; for since the wires pull in opposite directions, the posts are kept perfectly erect and steady.

Fig. 185.

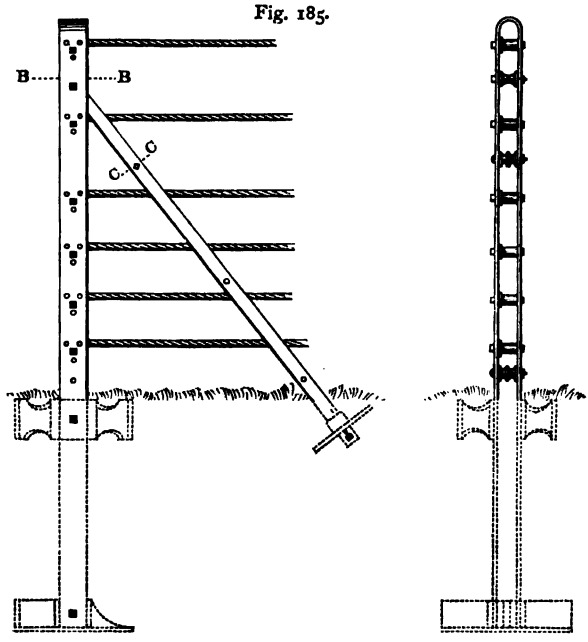
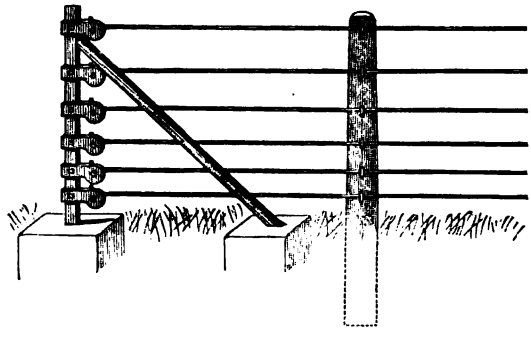


Fig. 186 shows still another form, called the iron ratchet straining-pillar. That shown in the figure forms the extreme end of a wire fence with wooden uprights; but they can be had to strain both ways in the centre of a fence, in the same manner as those already

Fig. 186.

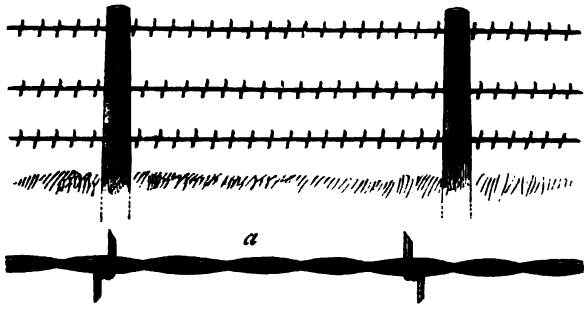


mentioned. Their construction is quite simple, the ratchets being attached to the post by plates bolted on each side, and they can be tightened up or slackened by the key at any time. They are

batted into stone, and have a strong iron stay when the strainer is at the end of a fence or at an angle. That shown in the figure being at the end of a fence, and straining only from one side, has a stay which is also batted into stone in the usual way. This kind of straining-pillar can also be had with self-fixing bases, which obviate the necessity of any stones whatever.

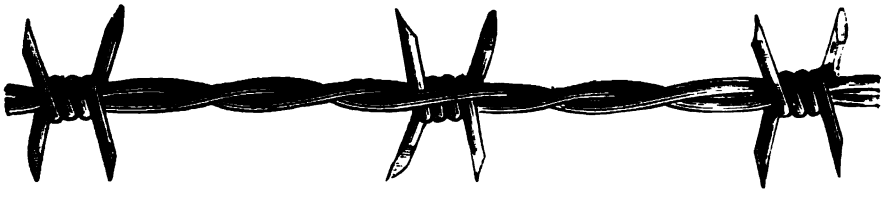
Barb-Fences.—Under this branch of wire-fencing mention may most conveniently be made of the **barb-wire** fence which has been in-

Fig. 187.



troduced into this country from America, and which, though extremely mischievous and dangerous in a hunting country, is yet unequalled for efficacy and cheapness as a fence; for although the barb-wire itself is dearer than ordinary wire, yet a smaller number of strands is requisite to exclude animals, whose skin is lacerated in a painful manner by the barbs. It is rather peculiar in its construction when compared with our commonly used wire-fences. Fig. 187 will give

Fig. 188.



an idea of this kind of fence. It can either be erected on wooden or iron straining-posts, with wooden intermediates; the straining-posts being the same as those used for a common fence with iron strainers and wooden intermediates, as already described.

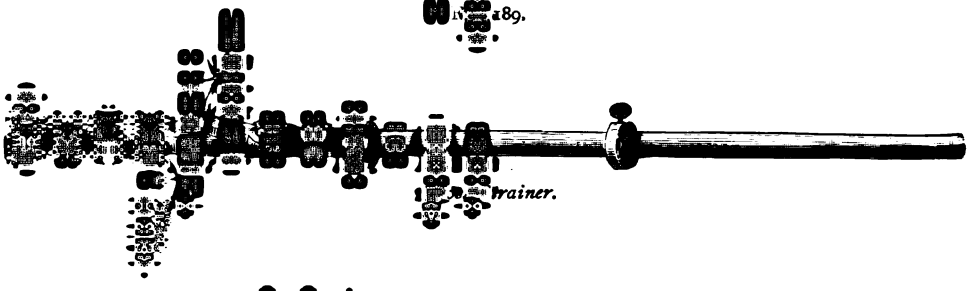
This fencing material is made of steel, and is composed of two strands, with two or four **barbs** projecting at right angles every few inches, as shown in Fig. 188. Three lines of this barbed strand are usually found sufficient for a fence of ordinary height, as cattle will

once coming in contact with the might be used as a top-wire in or with a second line in the middle d in "spools" of about 400 yards e ordinary staples.

wooden posts, the following general

ft. from the corner posts and from dded in the ground.

189.



trainer.

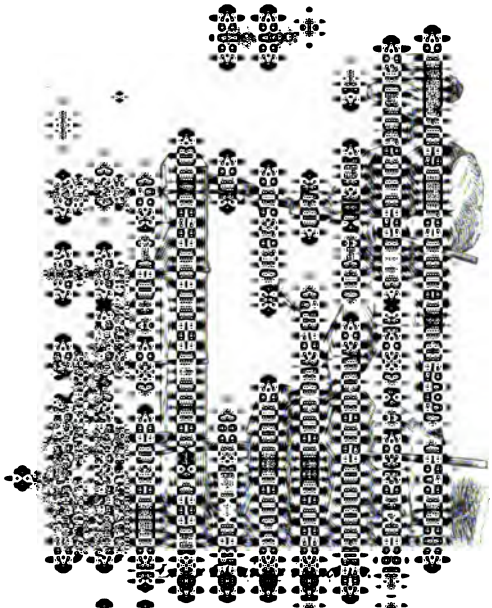


Fig. 191.

Winder Strainer in action.

ach line of fencing is to cross it.
of a spool of fencing to the first
thereon, then proceed to carry the
oposed fence, allowing the wire to

m the spool, raise it to its proper

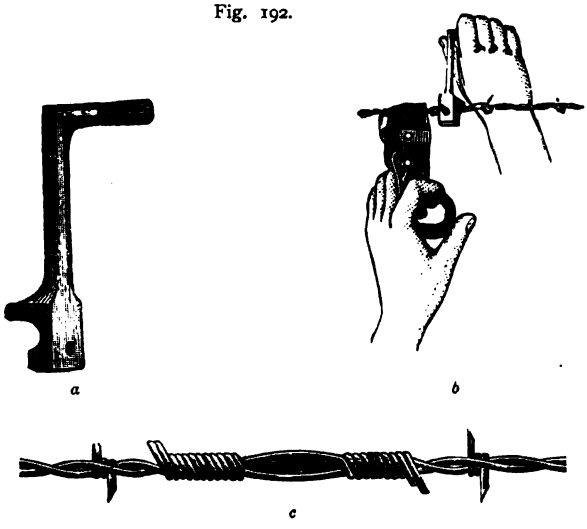
place on each *main* post and to the next corner post, stapling loosely to each post.

5. Draw the line from the starting-point to the first main post as straight as convenient with the hands; then at the said main post apply the "strainer," and strain rigidly to place. While the line is thus under strain, staple firmly to each intermediate post as well as to the main post. Repeat from the first main post to the next, and so on until the next corner post is reached.

The instruments used in straining are the lever-strainer for short lengths and the winding strainer for longer lengths. (See Figs. 189, 190, and 191.)

An ingenious method of joining barbed wire is exhibited in the

Fig. 192.



a. The Splicer. b. Pincers and Splicer in action. c. The Joint when completed.

pincers and splicer of Messrs Bayliss, Jones, & Bayliss, Wolverhampton (see Fig. 192). The figure illustrates the method of making a joint with the pincers and splicer. The ends of wire are untwisted, and after removal of the barbs, laid side by side for 8 to 10 in., then gripped firmly by the pincers, held in the left hand, and with the splicer the loose ends of the wire are wound round the main wire in the manner shown above. The grip of the pincers is obtained by an eccentric, and therefore no strain is thrown on the wrist.

Various standards are in use for supporting the barb-wire. One of the simplest of these is the method of Messrs A. & J. Main & Co., Glasgow, shown in Fig. 193.

III.—Wire Fences erected upon Iron Straining-Pillars with Iron Standards.—Reference must now be made to the putting up of

wire-fences upon iron posts or uprights. As so much detail has been given relative to the erection of the other two classes of wire-fences already referred to, it will not be necessary to enter into minutiæ about the erecting of iron fences, seeing that they are put up upon the same principle as the others. It will be sufficient merely to note the chief peculiarities of this class as compared with the others, mentioning at the same time the most approved kinds of fences now erected.

Fig. 193.

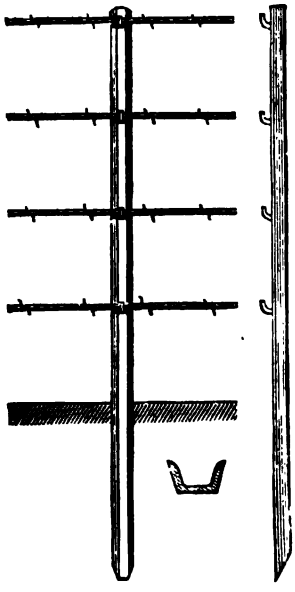
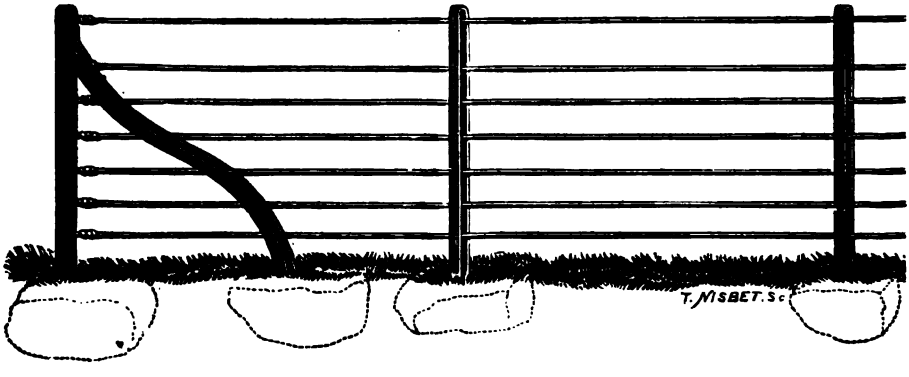


Fig. 194 represents a 4-ft. wire-fence upon iron uprights, having 7 horizontal wires. The straining-pillars are generally of wrought-iron, and are placed about 100 yards apart in the line of fence, with stays for the ends of the fence; but they may also be made of cast-iron. The straining-post, *a*, is sunk and batted well into a large stone, which may either be undressed (as in Fig. 194) or dressed square (as in Fig. 195). The stay, *d*, is also well sunk and batted into a large stone; and in putting in these stones, they should be firmly bedded into the ground, so as not to yield afterwards by the strain of the wire. The stay is of double iron, for allowing the wires to pass through between each piece. The standards, *b*, are $1\frac{1}{2}$ in. by $\frac{3}{8}$ of an inch; they are placed at 6 ft. apart,

Fig. 194.

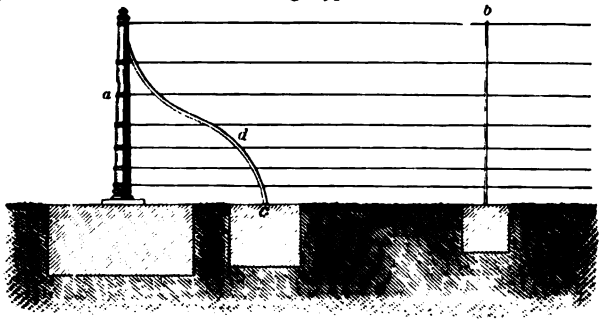


and also sunk into stones of about 12 in. cube. This class of fence will resist the heaviest stock.

It is not absolutely necessary that the description of wire-fences

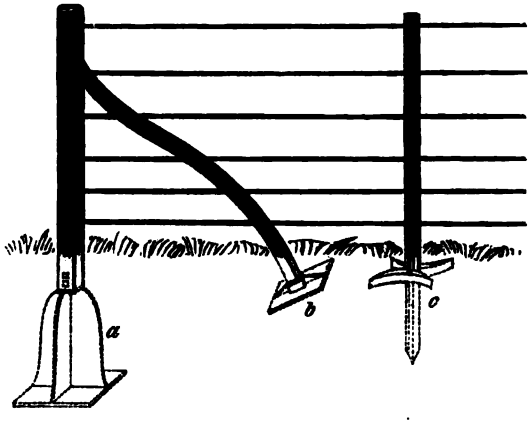
now under notice should always have the straining-pillars and standards sunk and batted into stones; for now, with iron bases and earth-plates fixed to them, a fence equally strong can be put up without their use. A reference to Fig. 196 will at a glance show how the stability of the fence may be secured without the use of batting-stones.

Fig. 195.



In this figure, the base of the terminal straining-pillar is shown as sunk in the ground at *a*, and that of its stay at *b*. The base of the standard, which is shown at *c*, consists of what is called a cast-iron earth-plate. This fence is 4 ft. high, and has 6 lines of galvanised strand or rope-wire. It has a patent winding straining-pillar with

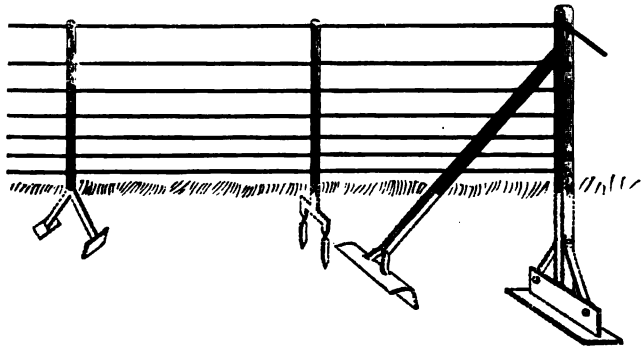
Fig. 196.



self-fixing base every 200 yards, and strong T-iron standards every 9 ft., with cast-iron earth-plates, already mentioned. Fences of the above description, together with many others constructed on similar principles, are manufactured by Messrs Bayliss, Jones, & Bayliss, Victoria Works, Wolverhampton; Messrs Boulton & Paul, Rose Lane Works, Norwich; Messrs A. & J. Main & Co., Clydesdale Iron-

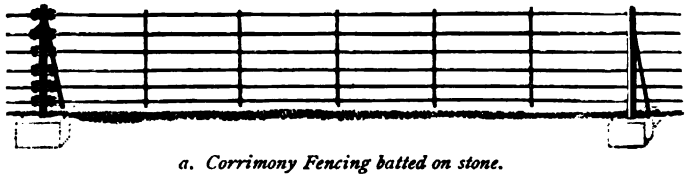
works, Possilpark, Glasgow, and other firms of high standing. Iron fences erected on this principle are quite as strong and secure as those with all the uprights batted in stones; whilst they have the advantages that they are less costly to fix, and are better capable of removal elsewhere whenever this may be required.

Fig. 197.

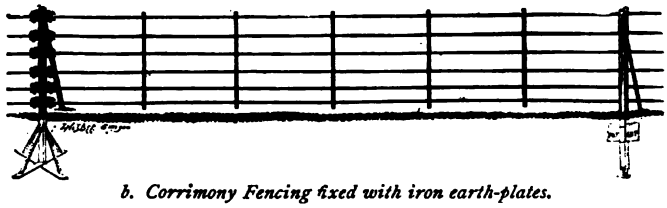


Nor is it necessary in all cases to have the intermediates made with self-fixing bases or earth-plates, as an equally strong fence can be made with double-pronged intermediates. Fig. 197 shows a good substantial fence, 4½ ft. high, with 7 wires, the standards being placed

Fig. 198.



a. Corrimony Fencing batted on stone.



b. Corrimony Fencing fixed with iron earth-plates.

8 ft. apart, and made of wrought-iron of 1½ in. by ⅜ of an inch, having double-pronged and anchor-formed self-fixing feet alternately. The straining-pillars, which are also of wrought-iron, fitted with improved winding-gear, have double stays, all with self-fixing bases, and are placed 100 yards apart. This fence is adapted for heavy stock and

the most exposed situations. It is manufactured by Messrs Hill & Smith, Brierley Hill Ironworks, near Dudley.

A very efficient system of iron-fencing was introduced in 1873 into this country from New Zealand by Mr Ogilvy of Corrymony, Inverness-shire, which is now known as the **Corrimony fence** (Fig. 198). The main difference between this fence and an ordinary strained wire-fence is that the Corrimony fencing consists of wrought-iron winding straining-pillars and solid resisting pillars, placed alternately on an average of nine to the mile, and either batted on stones or else fixed by means of patent earth-plates (see Fig. 199). Iron standards, which have stays attached to them, are placed generally about 18 yards apart, and the horizontal wires in connection with these are made of steel, and are of sizes varying according to the required strength of the fence. Threaded upon these wires, and between the standards, are what are called **droppers**, or intermediate uprights, placed 6 ft. apart. They are not fixed in the ground, but hang upon the wires, and do not touch the ground; they are made of light iron, and are fixed to the wires with iron wedges; whilst they can be fixed to the wires with staples or holdfast clips as in Fig. 199. In a fence of this kind it is particularly necessary that both straining-pillars and standards be very securely fixed in the ground, seeing that they are so far apart as compared with other fences. The droppers do not give any strength or stability to the fence, but merely keep the wires at their proper distances apart. They are not fixed until after the wires have been strained. Fig. 200 shows another method of fixing them than the

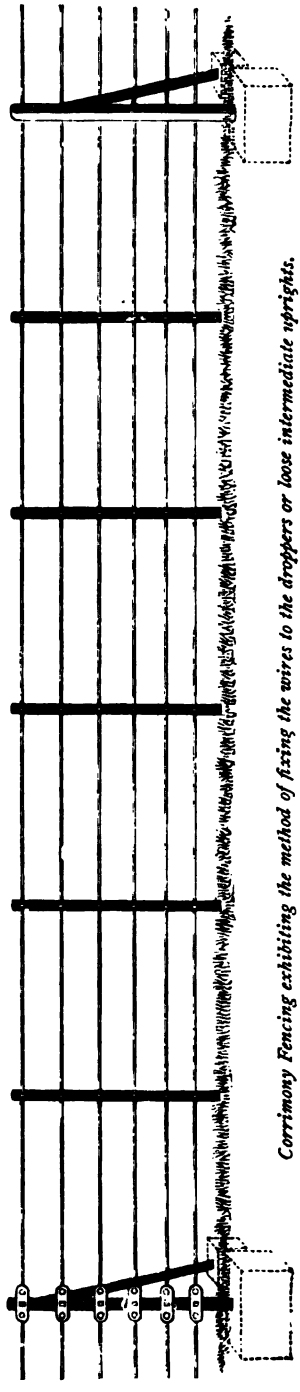


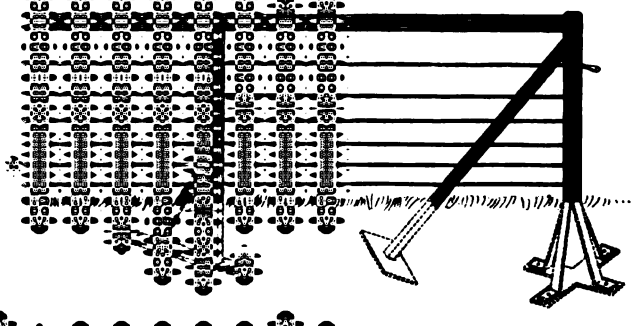
Fig. 199. *Corrimony Fencing exhibiting the method of fixing the wires to the droppers or loose intermediate uprights.*

(Fig. 199). Here the dropper, *a*, is is securely held in its place by ally prevents the dropper from arrangement the dropper may necessary.

tested in many parts of Scotland, r various kinds of ground. It m the home-grounds surrounding xposed situations; and it can be y recommended as a fence either policies, or for hilly and outlying here cattle and sheep are grazing. Bessemer steel wire is used in it is lighter, stronger, and more an common wire, though of course t more expensive. For sheep it is economical fence that has yet nted; and when strengthened and it also answers as a fence for ttle and deer. For sheep, it costs 5 to £50 a mile plain, or £56 to mile must be added if the fence nd deer.

b on account of their being danger- cts, as accidents are very likely to fence of this kind are not readily get entangled in them, and the rider are brought heavily to the

Fig. 201.

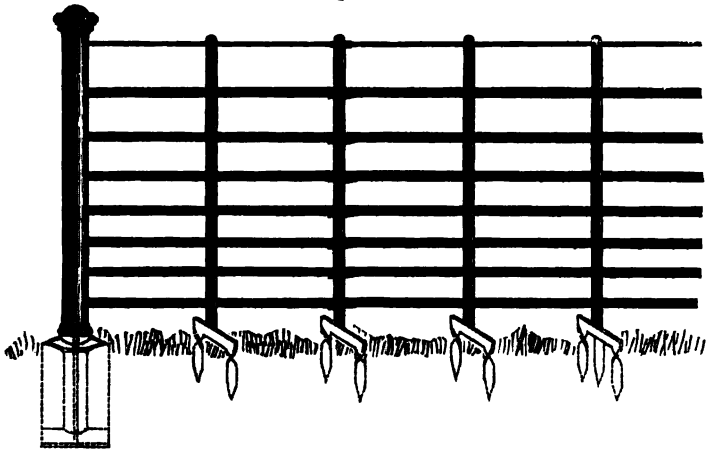


erous accidents of this sort a very by having a Larch rafter on the wn in Fig. 201. The fence here the ground, and has 6 lines of

wire, with a Larch rafter on the top, which should not be less than 3 in. by $\frac{7}{8}$ of an in. The standards of angle-iron are placed at 7 ft. apart and 18 in. under ground, while the straining-pillars are on the self-winding principle, and are placed every 200 yards apart. These have self-fixing bases, as shown in the figure. Of course the number of wires can be determined according to the height of the fence, or the fence can even be made with a top-wire as usual, and the rafter put on or taken off when necessary.

There is yet another variety, the continuous wrought-iron fencing, to be referred to under this heading. This kind of fence is now so generally known in the country, that it is not necessary to give any lengthened description of it here. It is manufactured of different heights, to suit various purposes; but by a reference to Fig. 202,

Fig. 202.



which represents a fence of the above nature suitable for deer-parks, a good idea of its construction will at once be obtained. This deer-fence has eight bars, the topmost being of round iron $\frac{3}{4}$ of an in. in diameter, joined in every fourth standard by means of an improved ferrule-joint; the other bars are of flat iron, 1 in. wide by $\frac{1}{4}$ of an in. thick, and are placed with their edges downwards, and connected together by means of an overlap notched joint. The standards are placed 3 ft. 9 in. apart, and are made with double-pronged feet. The size of the standards at which the horizontal bars join is $1\frac{3}{4}$ in. wide by $\frac{3}{8}$ of an in. thick; while the intermediate ones are $1\frac{1}{2}$ in. wide by $\frac{3}{8}$ of an in. thick. The whole fence is 6 ft. high above ground, and 18 in. below. This is a very durable fence, and one great advantage which it possesses is that it can be easily fixed in curved lines, and can at any time be taken up and removed to another place with little

trouble. It does not require any side-stays, neither does it need stones or wooden blocks, nor do holes want to be dug in erecting it. It is preferable to wire-fencing for the divisions of deer-parks, owing to the readiness with which it can be removed, and to its being easily seen by stock of any kind, thus causing much less danger than a common wire-fence would if used for the same purpose.

As has already been mentioned, fences of this sort can be had of various heights. If preferred, the whole of the bars can be made of round iron, like the top one shown in the last figure; or the top bar can be made of square iron, according to taste and circumstances. A fence of this kind, 3 ft. 9 in. high, is excellent for cattle and horses, while one of 4 ft. or 4½ ft. high will resist the heaviest stock. For pleasure-grounds and other situations they are made with a turn-over top, and with a chain above instead of a wire. In short, there are so many different patterns of this continuous fence, that to attempt to enumerate and describe them all would take up too much space, and would at the same time serve little practical purpose, as admirable illustrations of them are to be found in the catalogues of wire-fence manufacturers.

When a fence is required to be made game-proof, or to serve the purpose of protecting young plantations of trees from hares and rabbits, wire-netting is put on along the bottom, generally to the height of 2½ or 3 ft. The size of mesh most suitable for making a fence game-proof is 1½ in., but of course it can be had of any size. It can be fixed on any wire-fence, and should have about 3 in. put below the ground, in order more effectually to prevent rabbits burrowing under it. The price of this netting varies according to the height and size of mesh, but it can be had on application from any of the manufacturers of iron fencing.

Excellent fencing of the Corrymony description may be seen in the Athole Valley and Strath Tay in Perthshire, where plantations have to be fenced against sheep and hares, blue hares (*Lepus variabilis*) in particular. It consists of about five strands of wire, the top row of which is barb-wire, whilst wire-netting is attached to the lower strands from the ground-level up to a height of about 2½ ft. This forms a perfect security against hares. At some of the moorland and hillside plantations of small extent beaten tracks may be seen in winter when snow lies on the ground, showing that the hares travel round the fencing in order to try and gain an entrance. All gates must, of course, be protected in the same way. Against rabbits a width of wire-netting is not of itself a sufficient fence, as, unless the lower part of it be brought about 4 or 5 in. below the surface of the ground, the wire-netting will not prevent the rabbits getting past it by burrowing. In bringing it under the surface of the soil, it is of advantage to bend it slightly forwards towards the outside.

Regarding the cost of material and of erection in putting up wire-fences entirely made of iron it is unnecessary to say much, as there

are so many catalogues of prices and other particulars yearly issued by all the chief makers. Moreover, prices fluctuate from time to time; but general rates for the Corrymony fencing have already been given by way of example (see page 72).

In describing the principal kinds of wire-fences erected upon iron straining-pillars and intermediates, mention has been made of all the differences worthy of notice between the erecting of a wire-fence upon iron posts and one upon wood. In the actual erection of the two classes of fences the same implements are used, and the same method of working is pursued from beginning to end. It is therefore quite unnecessary to repeat what has already been said with regard to the erection of wood-post fences. The only real difference is, that in the erection of a wire-fence upon iron posts, these are either sunk into stones or have self-fixing bases or double-pronged feet. When stones are used, they should all be covered with about 3 in. of earth. In order to prevent strong animals from pressing the iron uprights to a side, they are often **wedged**. This operation consists in inserting a small iron wedge, or nail without a head, into two of the holes in each standard, say one at the top wire and one in the middle, and immediately above the wire. This should not be done, however, until the standards are made perfectly plumb and the fence finished, when the wedges should be driven in firmly; but at the same time they ought to be put in so that they can be readily driven out again at any time when the wires require to be re-strained. In all wire-fences with iron standards, where curves occur in a line, it is also necessary to have iron stays put to the standards on the inside of the curve, so as to give additional strength against the strain.

In erecting wire-fences wholly on iron uprights, the winding and straining pillars are usually placed in the middle of the line when there are long lengths to put up; and in applying them to this class of fences, the work is performed in all respects as has been described with reference to the fences with iron strainers and wooden intermediates.

It may further be added that all wire-fences, whether upon wooden or iron posts, should have the ironwork painted each year for the first two years after being erected; after that period each second year will be enough. Black varnish is now extensively used for this purpose, and proves a very good preservative for iron fencing. In the summer time the wires of all these fences are apt to expand in warm weather, and consequently become slack; consequently the screwed eye-bolts or the winding-rollers, as the case may be, should be put in operation to have them tightened up again. In the winter season, particularly during frost, the wire always contracts to a considerable extent, thus causing the wires to become over-tight; conse-

quently in such cases they require to be slackened. If these practical points be not attended to, the wire may break during the winter and sometimes allow cattle to escape, and may be apt to become too loose in summer. A great deal of trouble of this kind is often, however, caused owing to the fences being made of inferior wire. All good wire should tie cold—that is to say, it should knot without being subjected to any heating in a fire. A really good fence that is put up with good wire should not give any great amount of trouble, either in the way of straining or in being subject to breakages.

With regard to the most suitable material for batting iron standards into stone, a general preference is given either to lead or to what is known as **lava cement.** Lead has been used to a great extent in most parts of the country, and has given satisfaction in nearly all cases. It has, however, the disadvantage of being somewhat costly; and if the hole be not properly filled up, the standard may become loose. Good lava cement is a capital substitute for lead, for it does not injure the iron in any way, as sulphur often does. This cement sets very quickly, is very hard, and is altogether just about as good a material for batting iron standards into stone as can be had. Of course, whatever kind of batting material is used, the fence should get all justice by being well kept free of rust, as much harm is often done to an iron fence by rust, the cause of which is very usually attributed to a bad batting material. Straining-pillars should generally be sunk 5 in., stays or struts 4 in., and standards 3 in. into the stones; but as a great deal depends upon the quality of the stone and the size of the standards or straining pillars, these details must be decided by the given local circumstances of each case.

Extensive experience in the erection of wire-fences goes to prove that they should be all put up on iron straining-pillars, of one or other of the kinds above described. Wherever this mode has been adopted, the fences answer admirably, both as regards strength, durability, and neatness of appearance. In fact, a wire-fence put up on this principle may be truly said to be almost indestructible by time, if properly attended to and kept in order. For although the intermediate posts may be of wood, which will rot and give way, yet the iron strainers remain as they were when put up; whilst the wooden posts of the fence can be easily removed at any time, and new ones put in, so as to make the whole as good as when new. Although a wire-fence erected on iron straining-pillars, with wooden intermediates, is as suitable as any other for resisting heavy cattle, yet fences of this description have now, for several years past, generally been superseded by those erected wholly of iron. As remarked at the beginning of this section, this may be truly said to be the "iron age" with respect to fencing and enclosures. Fences erected entirely of iron have certainly

a neater appearance than those with wooden intermediates, and have likewise the advantage of lasting for a far greater length of time without requiring repairs. Although to a proprietor who has plenty of good Larch timber of his own at hand, with which he could readily put up a fence having wooden intermediates, an iron fence may seem an unnecessary expense at first, yet it will be found that it will be the cheapest enclosure in the end. Looking at the price of timber, it will be found that, even when newly erected, there is in many localities little difference between the two. Iron fences can also be made to stand as much pressure from cattle as those with wooden intermediates; so that, taking everything into consideration, the only opinion that can be expressed on this matter is that wire fences, consisting entirely of iron as regards straining-pillars, standards, and stays, are most suitable for general practical purposes; for they have greater durability, and can, if need be, be more easily shifted or removed elsewhere, when no longer required at any particular locality.

The choice of the use of wood or iron is a matter that really only concerns the individual proprietors themselves, as they may find the one or the other more suitable for their purposes.

Fencing of Park Trees.—There are few landed proprietors' seats in Britain so perfectly adorned with all the known ornamental and useful sorts of trees that they may not now and then receive an additional embellishment in the form of some new and highly interesting foreign species. Indeed, however complete any home-park may be as to its collection of useful and ornamental trees, the proprietor will probably take pleasure in transferring good specimens from the enclosures of shrubberies, &c., to the open parks, where they are sure to develop to advantage, and to prove ornamental by their contrast with other sorts, when judiciously arranged among these. In order to protect such specimens from being injured by cattle that may be grazing in the park where they are planted, it is of primary importance for their future welfare that the trees should have a fence of some sort put round them, for a time at least. When such trees have outgrown the reach of danger of this kind, the fencing should be removed; for it must be admitted that a tree growing without any protection whatever is in all cases a more picturesque object than one having a fence about it. But wherever it is found necessary to have single trees protected for a time from the effects of animals, this should be done in as ornamental a manner as possible.

There are many kinds of **tree-guards** used for the protection of single trees. They vary in appearance from the simple wooden posts with rails, to the neat and often highly ornamental fence of iron.

Wooden tree-guards are, however, practically out of date, having

[illegible] UARDS.

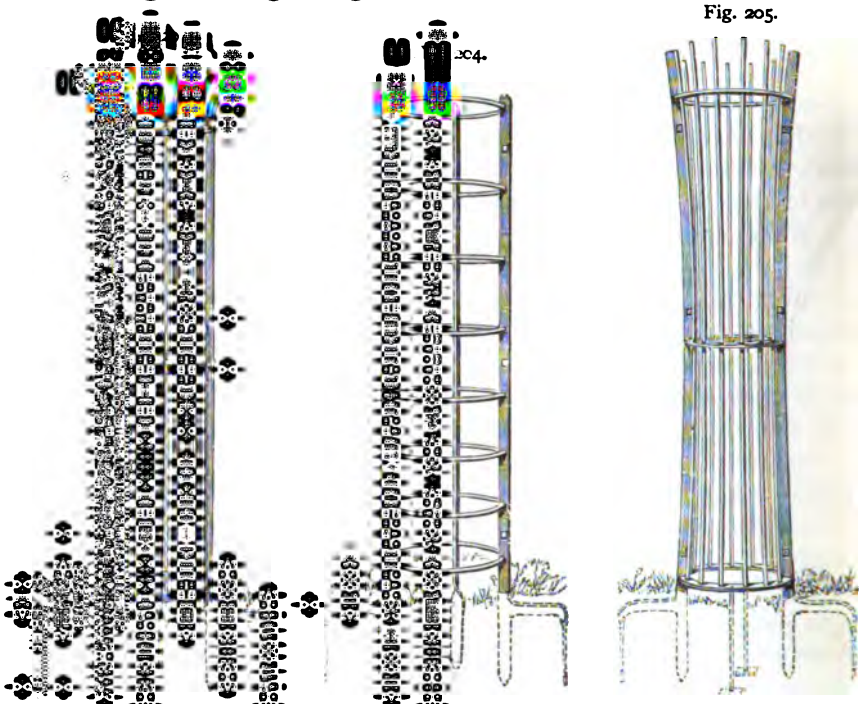
[illegible] e use of wrought-iron guards of [illegible] al, designs.

[illegible] expensive for use on any very exten- [illegible] e conducted largely, as, for example, [illegible] ging coniferous crops, or where com- [illegible] en planted out for any special purpose [illegible] Continental method is to bind furze or [illegible] s securely with wire, or else to coat [illegible] ith some objectionable mixture (see [illegible] *dlands*, 1893, pp. 93 *et seq.*).

[illegible] tree-guards are distinguishable— [illegible] s; (2) those for larger home-park

Fig. 205.

[illegible] 204.



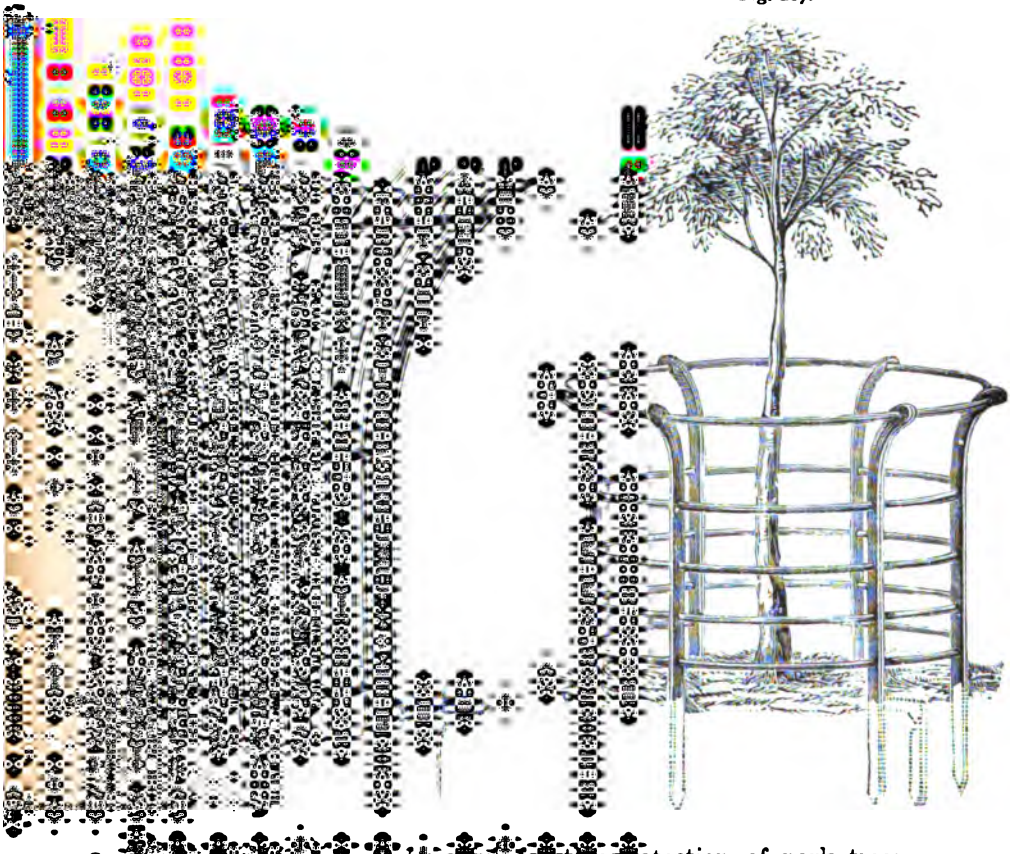
[illegible] owns. According as they may be [illegible] cial purposes, they vary essentially [illegible] actically constructed upon the same [illegible] o parts and bolted together. And [illegible] otection of certain individual trees, [illegible] d elsewhere.

[illegible] venues.—These form an efficient [illegible] They are easily fixed, being made [illegible] r with bolts and nuts. Specimens

[illegible] 5. They stand about [illegible] lower part, are not in- [illegible] bout half their height. [illegible] e, sometimes broader; [illegible] 6 to 18 in. in diameter [illegible]

[illegible] only from about 3½ [illegible] r in being invariably [illegible] d 207).

Fig. 207.



[illegible] otection of park trees. [illegible] le to the eye than the [illegible] ely durable. They are [illegible] ured together by bolts [illegible]

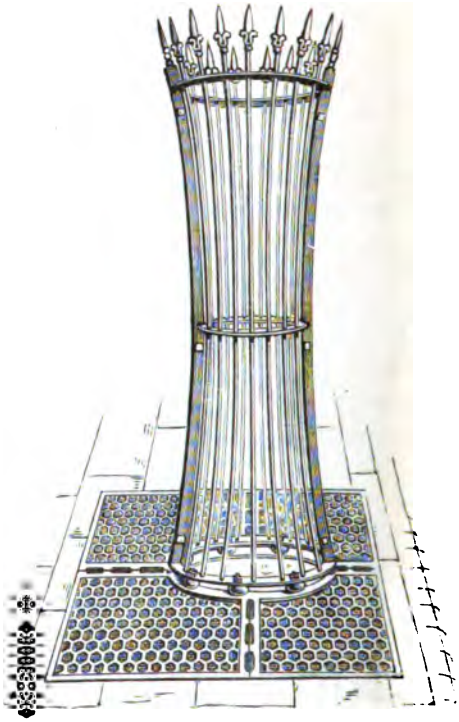
[illegible] ther of the above two [illegible] ornate character.

gs. 208 and 209 are specially suit-
hey effectually protect young trees

ground, by 18 in. diameter at top
centre.

ar form of guard best suited for
e trees to be protected are growing
e best form for placing round trees
both of the class termed unclimb-

Fig. 209.

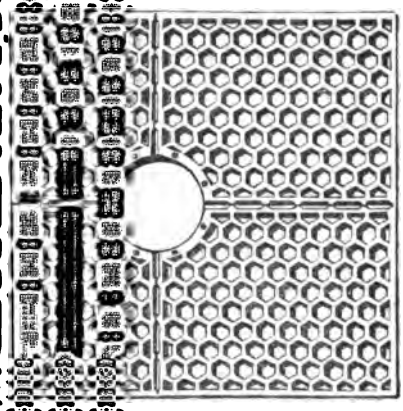


ard is fixed to a grating, admitting
d atmospheric oxygen, which is so
movable in order to allow of the soil
eration. Tree-guards of the above
Messrs Bayliss, Jones, & Bayliss,
firms mentioned as specialists with

Colonies.—In nearly all the agri-
tes of North America wooden fences
ubdivision of fields, and these are

"snake-fence" as it is
nce.
ed of rails about 4 in.

Fig. 210.



ney are properly in their
closely embraced by the
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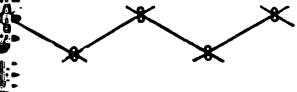
Fig. 211.



re. This sort of fence
United States where
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uch as pigs; the second
laced about 5 in. above
road, and is placed 6 in.
also 6 in. broad, and is
e is thus made about 5
t of fence are generally
firmly put together, this

makes a substantial fence, which will last for a considerable number of years.

Of late years, however, a great extent of wire-fence has been erected in the United States, and more particularly on grazing farms on the Prairie and Western States, where timber is scarce and high priced. These are largely formed of barb-wire, which was introduced into Britain from America.

In parts of the United States where stones are abundant, stone walls are in general use. They are often erected of a very substantial nature, and even topped with wire, so as in all respects to form fences of a first-rate character.

Hedging has hitherto been much neglected in all parts of the Union, most probably owing to the expense that this class of fences entails during the first few years of their growth. This is, however, a short-sighted policy; for hedges, when once properly established on an estate, and skilfully managed, will stand good against several successive wooden erections as fences. And besides this, they will produce a degree of shelter never obtainable from palings or wire-fences of any description. Hedges are to be found in many parts of the States, however—though, generally speaking, only on the properties of the wealthier and more intelligent farmers, who have observed the advantages arising to their stock and crops from this class of fences. North American farmers might therefore well take into consideration that wooden fences are only of a temporary nature, and give little or no shelter to their lands; while hedges, when well managed, last for generations, and produce much beneficial shelter, thus causing the fields to produce early crops, and preserving the herbage to the latest period possible in the fall of the year.

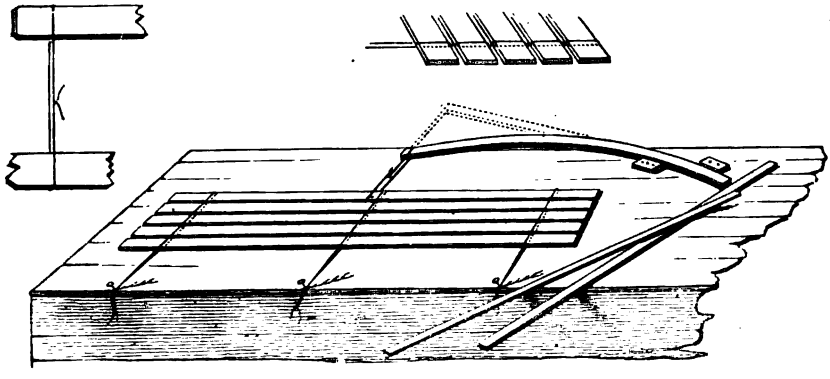
In many parts of the States fruit-trees are subject to attacks of rabbits, to injury of the trunk by severe cold during winter, and to sun-burn during the heat of summer. In order to overcome these dangers the following plan has been adopted (*Report of the Secretary of Agriculture*, Division of Pomology, 1892, p. 267):—

"**A Tree Protector.**—There is a pressing need for something to prevent injury to the trunks of trees. In the central Prairie States, in particular, rabbits often destroy whole orchards by gnawing off the bark in winter-time. In Texas I have seen the same thing occur in midsummer, as rabbits are usually numerous there. In the extreme Northern States the severity of the winter often causes the trunks of apple-trees to become diseased, and in some cases to die. The very hot sun in midsummer also seriously affects the south side of trees, making large blemishes which sometimes prove fatal.

"In addition to the testimony of many correspondents, I know, from about twenty years' personal experience in Kansas, that it is useless to depend on washes of any kind to prevent, under all circumstances, the depredations of rabbits. The only sure method is to surround the bodies of the trees with some material which they will not gnaw. Corn-stalks

and coarse grass tied fast with strings, hay, ropes, rags, and paper wound about them, are commonly used, and are cheap, but perishable, and have to be annually renewed. A piece of closely-woven wire netting, about 12 by 18 in., bent about the tree and fastened by a wire, makes a surer protection, and costs about 3 cents. It will also stop the eating of the bark by mice, and prevent the beetle of the round-headed borer from laying eggs, and will last for several years. A bunch of soft grass stuck in the top will keep it in proper position, and allow no chafing of the tree. Another cheap and durable protection is made from wire and plastering lath or other wooden strips. It has been used in a small way for many years, but only within the last three years has it been put prominently before the public. Mr A. J. Phillips, of Wisconsin, has led in this work. Professor E. S. Goff gave an accurate description of this method in the *Report of the Wisconsin Horticultural Society for* 1891. Cypress or Cedar plastering laths are best, where easily procured, but those of Pine will last very well. Cut in two pieces, they are about the right length, but longer strips can be used, if necessary, for the better protection of tall

Fig. 212.



Method of manufacture of Tree Protector.

trunks. Six laths make a protector large enough for a small tree, but seven or eight are more commonly needed to prevent renewal until the trees have attained an independent age. The accompanying drawings will in a measure explain themselves (Fig. 212 showing the method of manufacture, and Fig. 213 the protected tree). The following description of the protector and directions for making are quoted from Professor Goff, with some amendments :—

"'The wire used is about No. 18 in size, and may be of iron, brass, or copper. Brass and copper are more durable than iron, but their greater cost will overbalance this advantage. As a rapid means of measuring off the wire, it may be wound lengthwise about a piece of board 18 in. long for an eight-lath protector, or 16¼ in. if seven laths are to be used. The wires may then be cut at one end of the board with the cold chisel or tinner's shears. The protectors may be rapidly put together on a common work bench, by means of the simple device shown in Fig. 212. Procure a piece of strong elastic wood about 4 ft. long and ⅜ of an in. thick, to serve as the spring shown in the drawing. Then tack two blocks to the top of the bench near the rear side, to serve as a support for the spring. Now, drive three nails into the bench near the front side, at the distance apart at which the wires are to be placed on the protector. The end wire should be about

the ends of the wires together for a short
, and place one of the wires about each of
Place another shorter wire, having the ends
e drawing, about the outer end of the spring.
s shown in the drawing, bending the springs
ng now acts as a tension to keep the wires
lower strand of wire and slipping the lath
us crossing the two strands. Then with a
ard the first, till the two are about ¼ of an
same manner, after which unhook the wire
loosen it from the protector. In placing the
t the tree, simply bend it around and insert
f the wires beneath the wire of the first or
linching it enough to hold securely, as shown
The protector is to be left on summer and
the tree outgrows it, or the wires rust off.
not only prevents sunscald on the trunk, but
preventive from rabbits and other rodents,
m whiffle-trees used in cultivation.'"

it regard to fences in Canada, they
ally of the same descriptions as
the United States, the zigzag or
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and there on the farms of the more
and wealthier classes. Wire-fencing
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stralia and New Zealand wire-fences
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carce in many parts of the country,
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the first erection than wooden ones.
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rial are in common use; they are of
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s are now beginning to plant hedges
ts of plants.

uch in the same position as it is
open sheep-runs and agricultural
fences; while, in the neighbourhood
of various designs and descriptions

erent kinds of fences—the thorn-
and-lime wall, the dry-stone dyke,

the turf-dyke, wooden paling, and wire-fence, both upon wooden and iron uprights—are not alike suitable for use in all situations and for all purposes; hence it may be of use to point out the special qualities possessed by one or other of these different classes under given circumstances and conditions of different localities.

The Hawthorn Hedge.—For the subdivision of strong clay and heavy, loamy, arable lands, perhaps no fence is so suitable, whether in respect to neatness, picturesqueness, durability, or shelter, as the Thorn-hedge; for in such soils it lives long, has a strong and healthy growth, and makes an admirable fence.

The Thorn-hedge, with a mixture of Beech-plants, is of all other fences the best adapted for a situation where a neat and clothed appearance is the object. And this it always has unless carried to a situation more than 1000 ft. above the level of the sea, or unless, up to that altitude, it be planted in a mossy or light soil; for there it will not live long, except upon loamy land.

In high and exposed situations, hedge-fences are excellently adapted for the division of fields; and even in such situations no fence ultimately answers better than the Beech-hedge. Such a fence, even although on a light soil and in a high exposure, will, under careful management, keep good and be an ornament when dykes and palings of the same age are tumbling down and useless. It is well known that many object to the raising of hedges with Beech and Thorn in high parts of the country, asserting that the Thorn does not succeed. Practical experience, however, shows that upon many estates there are good hedges of Beech and Thorn more than 900 ft. above the level of the sea, and that at the same time they maintain themselves in excellent health. But on very high parts of the country, and on very light lands, a better fence is secured by using Beech alone than by mixing it along with Thorns; as the Beech is not only hardier, but better adapted to grow healthily on high lands. If any mixture be desired, a sprinkling of Hornbeam may be put to the Beech.

The Furze-Hedge is unquestionably one which should be kept out of all cultivated districts. There is no situation where the Furze is found growing as a fence, in which Beech would not thrive much better; for Furze belongs to the class of weeds which should be extirpated from the vicinity of woodlands rather than encouraged in growth so that their seeds may be borne into the interior of the plantations.

The Stone-and-Lime Wall is of all others the most substantial fence that can be erected; but, as it is an expensive one, it cannot properly be carried to any great extent. No landed proprietor's policy-grounds can, however, be said to be complete, as regards general

security, unless they be surrounded by a stone-and-lime wall of from 6 to 8 ft. high. In fact, the residential portions of good estates should be surrounded and protected by a good high wall; and the best of seats always are surrounded thus. But in no other case is it necessary to erect a stone-and-lime wall as a fence, unless where sunk fences have to be formed, as, for example, upon the slopes of rising ground. Upon level ground, if it be desired to have an invisible fence, as the sunk fence is meant to be, a wire-fence is infinitely superior in every respect; and even in this particular matter it at the present day occupies much the same position that sunk fences occupied about a hundred years ago. A sunk fence is excellently adapted for any purpose whatever when built upon the slope of a hill or brae, as previously shown in Fig. 147; but in any other position it can hardly be said to have a utility corresponding to the expense of its erection.

The Dry-Stone Dyke is the best form of fence adapted for giving immediate shelter to young plantations or to other crops upon high and exposed parts of the country. Unlike any other fence, it is at once both a fence and a shelter; hence the reason that it is so much in request in all bare uncultivated districts. It at once gives the shelter which a good Hawthorn hedge can only yield after several years' growth.

Dry-stone dykes are, from their rugged and untrimmed appearance, not to be recommended as a fence where a neat and trim effect is meant to be kept up, as, for example, within the home-grounds of a landed proprietor. But upon high-lying parts of the country no fence is more commendable, whether as regards security, or shelter, or general picturesqueness of effect; for old dykes overgrown with moss and lichens are eminently in keeping with their surroundings on wild hills and moorlands like those of our Scottish Highlands.

The Turf-Dyke should never be made use of except on high-lying moorland districts, where stones are not easily obtainable, and where immediate shelter is wanted for sheep stock. From the temporary nature of the material of which it is made, it is constantly liable to injury by all kinds of heavy cattle; consequently it should not be erected where these are to be grazed. The only parts of the country where the turf dyke can be at all recommended is on high-lying sheep-pastures where shelter is wanted for the stock, where stone dykes cannot be easily erected, and where wire-fences are objectionable on account of their producing no shelter.

Wooden Palings are, in general, only considered as temporary or subordinate fences. In all cases where young hedges are planted, and where cattle of any description are to be grazed in the fields adjoining, the former must be protected by a wooden paling until

they have attained a size and strength sufficient to ensure their being exposed with safety; and this is the one use for which palings are in continual demand.

The horizontal paling is used principally for agricultural purposes, such as the protecting of hedge-fences in their young state, or for the mending of gaps in old hedges, &c. The upright paling is mostly used, in an endless number of varieties according to taste, as ornamental fences about gardens, cottages, &c.; and it forms excellent and useful fences when made of good Larch-wood, which will last longer than any other sort of timber for this purpose.

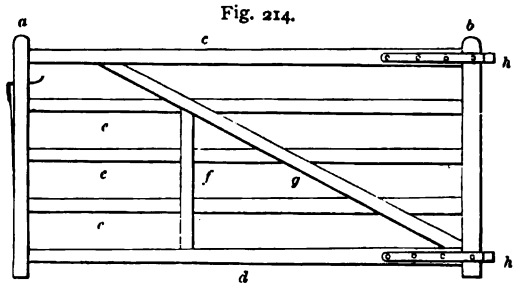
The Wire-Fence is, beyond all others, the most durable and ornamental, and at the same time the cheapest. It takes up scarcely any space between enclosures, and is therefore, of all fences, the most suitable for agricultural districts. Of course it is not capable of producing any appreciable degree of shelter; but where this is no object, as in purely sylvicultural operations, the wire-fence should be used in preference to any other. As a fence for young plantations it is now extensively used in all parts of the country, even in high-lying districts. Wherever the plantation is extensive wire answers the purpose perfectly, because in this case the trees soon give shelter to each other, and do not require it from a fence; but, in the case of small plantations, these thrive better when protected by a fence calculated to produce shelter at once, such as a stone dyke. The wire-fence on wooden intermediates, with improved iron straining-posts, is that best adapted for all agricultural and woodland purposes, as the wooden intermediates are not apt to be in any way disturbed by the pressure of heavy cattle. Where the nearest possible approach to invisibility is wanted, however, as well as the greatest possible degree of permanency as a fence, the wire-fence wholly on iron uprights should be used; because this sort, when painted green, is not observable by any ordinary person till within a few yards of it, and will last, if well attended to, for a great length of time.

Fence-Gates.—As the making and hanging of gates is a branch of rural economy most frequently devolving upon the forester, it is important, and even necessary, to dedicate a section to the explanation of the most approved methods of making and hanging field and plantation gates; and, moreover, having said so much upon the nature of fencing in general, this chapter would be incomplete without a few observations regarding wrought-iron gates.

Every enclosed field and plantation of any considerable extent must have one or more entrances into it, in the form of openings in the fence which surrounds it; and these, again, must be made to act either as a fence or as an opening, as occasion may require. These openings are termed gateways, and whatever may be put upon them

to act as a fence is termed a **gate.** There are many forms of gates in use in different parts of the country, from the most rude horizontal spar, made to fall into a post at each end, to the fine massy iron gate hung upon hinges. It would be entirely out of place here even to attempt to enumerate all of the many different sorts of gates that may be considered of useful designs; the descriptions will therefore be confined to field-gates made of wood and of iron, as these are best adapted for plantation gates, and the most useful for all field and plantation purposes. **Wooden Gates** are generally made after the pattern depicted in Fig. 214. Gates of this construction are still very extensively used in many parts of the country, and are generally made of the best old Larch-wood or the best old Pine, which, when painted, lasts for a great number of years. As Larch-wood, however, is very apt to twist in the heat of the sun, to which it must always be greatly exposed when converted into a gate, it ought to be well seasoned before being used for this purpose. The following are the usual dimensions of a gate such as that shown in Fig. 214. The back

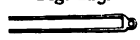
Fig. 214.



post, *b*, is 5 ft. high from bottom to top, and the scantling used in making it is 4½ by 2½ in. The front post, *a*, is also 5 ft. high from bottom to top, and the scantling 3½ by 2 in. The bottom and top horizontal bars, *c* and *d*, are each of equal dimensions, and about 9 ft. in length within the back and front posts. These are 4 in. broad at the joinings upon the back post *b*, and 3¼ in. broad at the joinings upon the front post *a*, by 2½ in. thick. The horizontal intermediates, *e e e*, are of course of the same length as the bottom and top bars, and of the same breadth; but they are only 1½ in. thick. The diagonal bar *g*, which reaches from the heel of the gate to within 18 in. of the point of the top bar, is of the same strength as the upper and lower bars, and, like them, tapers from 4 in. at heel to 3¼ in. at point; whilst the upright piece, *f*, is of the same dimensions as the intermediates, and reaches from the bottom bar to the diagonal at its junction with the second bar from the top. This gate is furnished with double hinges, which greatly strengthen the back part

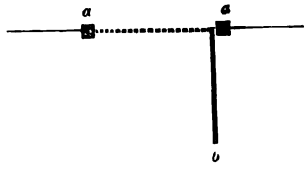
by clasping the joints both at bottom and top, *h h* (see Fig. 215, which is a representation of this double hinge). The peculiar properties of this form of gate are—(1) the back post, *b*, is much heavier than the front post, *a*, which tends to move the centre of gravity towards the hinges; (2) all the horizontal bars, from bottom to top, are made heavier behind than in front, with the express intention of lightening the gate in front, and throwing the centre of gravity as much as possible towards the hinges; and (3) the diagonal, *g*, is so placed that it acts as a lever against any weight which may be thrown upon the front part of the gate; for even its being lighter as it recedes from the heel is a great means of supporting the whole of the gate, and of keeping it well balanced. A gate made upon these principles most nearly approaches all that is required in such a construction; and upon this account such a gate as that now described appears to be of the best description possible, seeing that it combines strength with lightness in a very practical manner. In making this description of gate it is necessary, in order to attain durability as long as possible, to use only thoroughly seasoned wood, also to have the joints very neatly made, and all the parts planed smoothly, and painted with two coats of oil-paint before the gate is hung; whilst, even after they are hung in their place, such gates are much improved by being painted at least once in three years.

Fig. 215.



A few observations may very properly here be made upon the nature of hanging gates upon fences, both in fields and plantations; for errors are often committed in this apparently simple branch of the business of fencing. The common way of erecting gates is simply to hang them between the two posts put up for the purpose. By this method, when the gate is set open, it stands at right angles with the fence upon which it is placed (see Fig. 216, *b*); consequently it is in this state always liable to be injured by carts, &c., coming in contact with it when going into or returning out of the field or plantation. Another evil which almost invariably attends this old-fashioned method of hanging gates is that, from being hung from centre to centre of the two posts as indicated by the dotted line between the two posts *a a*, when anything goes wrong with either, the gate must be left too slack or confined too tight between them, according to the direction in which the post may have been driven; consequently the gate has a great chance of being injured in some way or other. And, besides this, it often happens that the posts are put into the ground without the addition of any other means of fixture, except being merely put into a hole and having the earth

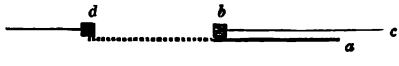
Fig. 216.



beat down firmly round about them. Again, if it should happen that the earth has been put in about the posts in a wet state, the certain result is that they will become slack in a short time, when the gate must fall down in front, and, in consequence of coming in contact with the ground, is soon either broken or much injured in the joints. If, however, the following method of hanging plantation and field gates be adopted, these results of bad construction are less likely to occur. Let the post upon which the gate is to be hung be about 9 in. on the side of the square, and let the part of it which is to be put into the ground be left round; then have this lower portion inserted into the ground to a depth of about 3 ft., and fixed upon a sole with a diagonal or stay, as has previously been recommended with regard to wire-fence posts (see Figs. 194–197). When the post has been made with its sole and stay on the under part, it should be put into the hole prepared for it, with the sole and stay projecting in the direction of the gateway, as this will ensure its stability against the weight of the gate or any other ordinary pressure in that direction; after this the post should be well packed with earth and firmed into the hole. But if the earth taken out be of a soft nature, then the pit had best be filled up with small stones mixed with earth, or any other substance, or cement of a hard and binding nature; whilst care should be most particularly taken not to fill in with earth in a soft or wet state, otherwise the work will almost be certain to fail of giving satisfaction. If thought necessary or desirable, the post upon which the gate is to be shut may be considerably smaller than the other; and it will not require to have any sole or stay attached to it, but may very safely be put into the earth at the same depth recommended for the former, care being taken to make it equally firm and secure by putting a large stone or two into the pit near the surface, which will add much to the stability of the post.

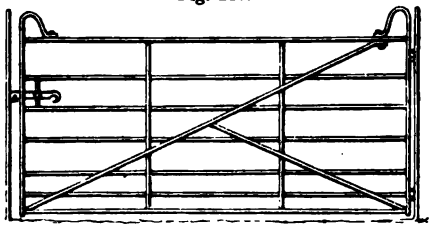
Having put the posts in plumb, and at the desired distance, which should always be the exact length of the gate to be put on, next have the crooks, upon which the gate is to be hung, put into the post on the angle of the same, instead of on the centre as in the former case. In Fig. 217, for example, the gate *a* is hung upon the corner or angle of the post *b*, and the effect of this is that the gate, when hung in this position, has full play upon the hinge to fold back upon the fence *c*, and is not hindered in its motion by the corner of the post, as must always be the case in the other method; and from the gate having room to fall back upon the fence when open, it is consequently entirely out of the way of any cart coming into or going out of the field. Again, instead of the gate being made to shut right

Fig. 217.



between the posts, it ought to be shut upon the face or outside of the shutting-post *d*, as is represented by the dotted line, which shows the position of the gate when shut; for in this case, no matter what accident may befall the post upon which the gate shuts, the gate itself is not likely to be injured. The upper crook of all gates of this description should be made long enough to go through the post, and should have about 2 in. of a screw upon the end of it, upon which a large nut is fitted for screwing; by this means, the crook will both keep its position, and will cause the gate to do the same.

Fig. 218.



Wrought-Iron Gates.—Many prefer iron gates to those made of wood, both for fields and plantations, for the very simple reason that they are more durable and lighter-looking. When of a proper construction, and rightly hung on wooden posts, they answer admirably; but practical experience often shows that they are more liable than wooden gates to get out of order from accidental contact with carts coming into or going out of the field or plantation. With careful work-people on a farm, however, iron gates are calculated to last much longer than wooden ones; and for the benefit of those who prefer the former, the following illustrations are given. One of the simplest constructions of iron fence-gates is that shown in Fig. 218, which follows almost precisely the same principle as the wooden gate shown in Fig. 214.

Fig. 219.

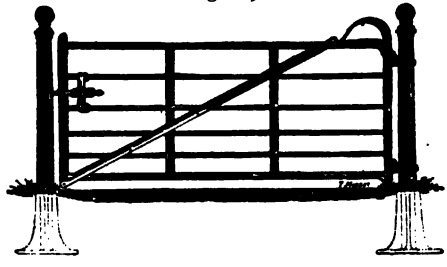
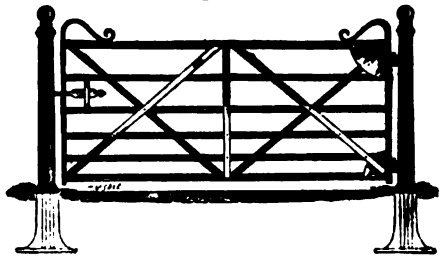


Fig. 220.



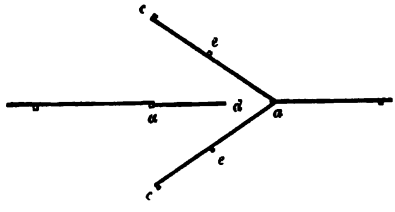
Gates of this pattern, 9 ft. wide, made of the best wrought-iron, and furnished with all the necessary mountings for fitting them on wooden posts, or for batting into stone, can be had at prices varying from 22s. 6d. upwards, according to their dimensions and the quantity of the material used in their construction. In using these iron gates, whether in fields or woods, it is often

preferable to hang them on wooden posts, and not on cast-iron pillars, because it is very often found in practice that where cast-iron pillars are used they are apt to get injured, or even broken, from very slight causes; while wooden posts are not so liable to this objection, but stand against any ordinary contact with carts, &c. Figs. 219 and 220 exhibit the most recent descriptions of fence-gates, as manufactured by Messrs A. & J. Main & Co., Glasgow, and the other fencing material manufacturers previously named.

When wire-netting is placed round fencing to keep out hares, it must of course be continued on to the gates; but as regards rabbits the matter is different, for the netting cannot be put 4 or 5 in. underground on the gateway.

Wickets.—It is often found convenient to have small wickets upon certain parts about gentlemen's grounds, particularly upon the edges of plantations through which pleasure-walks are made; and as it is frequently inconvenient to have such wickets to open and shut in the same manner as common gateways, it is desirable they should be constructed so as to be what may very properly be termed **self-shutting**. Of this description of self-shutting wickets none are more simple and effective, both as a fence and a gate, than that shown in Fig. 221, which is generally termed the **angular wicket**.

Fig. 221.



The opening in the fence, from *a* to *a*, may be about 4 ft. wide; the angular part of the wicket, *a e c*, may be about 3 ft. wide between *e* and *e*, and may be made up with any convenient sort of wood, according to taste. Care should be taken to have a post upon each of the extremities, and one at *e* upon each side, in order that the wicket *a d* may hit upon this as it folds to either side in the act of opening or shutting. The wicket *a d* may be made of light wood, and hung with a hinge upon a post at *a*. The particular recommendations of this sort of wicket are (1) that it is of a most simple and easy construction; (2) that it is easy for any person to have access through it, and that without the trouble of shutting or locking; and (3) that whatever description of cattle may be in the adjoining fields, they cannot pass through, seeing that if they attempt to enter, the wicket shuts before them upon the opposite side.

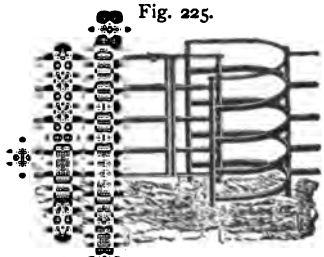
Other forms of wrought-iron wickets suitable for use in wire-fences are exhibited in Figs. 222 to 225, which are all of too simple a construction to call for any explanation. These range in price, as

[illegible] ow, from 15s. upwards,

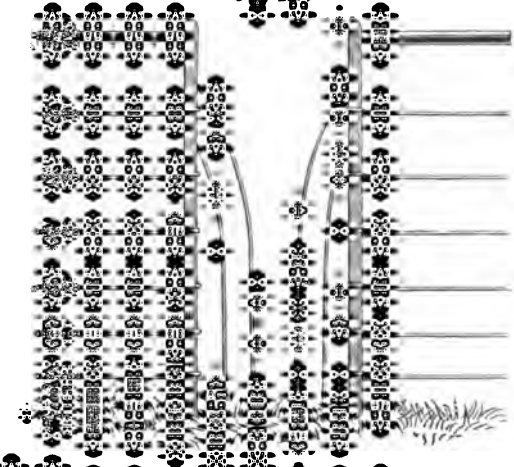
Fig. 223.

[illegible] he line of a wire fence, [illegible] ss is admirably adapted

Fig. 225.



[illegible] this pass is self-evident. [illegible] ays shut; it requires no



[illegible] t of order. It answers [illegible] of a large gate, which it [illegible] enerally shut.

Fence-Steps are, however, sometimes preferred in place of passes, and these may be made either of wood or of iron, as shown in Figs.

Fig. 227.

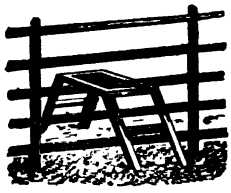
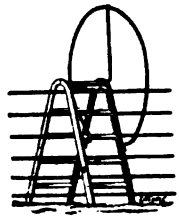


Fig. 228.



227 and 228. They allow persons to get over the fences easily without injuring the bars or wires. They cost from 15s. upwards, according to size and quality.

CHAPTER IX.

THE FORMATION AND MANAGEMENT OF NURSERIES.

Advantages of Home-Nurseries.—Every proprietor of land who has occasion to plant young forest-trees to any considerable extent should have a home-nursery or piece of ground adapted for the raising of young trees. Indeed, in the case of extensive hill and moorland properties, where a large extent of planting is annually and regularly carried on, and which are situated far from public nurseries, it often becomes an essential point of economy to establish also such temporary nurseries as may furnish adequate supplies of the young plants required. If forestry is to be practised as Sylviculture, and not merely as Arboriculture, throughout Britain in the future, then every proprietor should be his own nurseryman; for the raising of forest-trees to the requisite extent can easily be arranged for on most estates by the owners of woodlands, as is the rule on the Continent. But, where only a limited number of plants is required every year, it will prove quite as cheap, and perhaps, as a rule, decidedly cheaper, merely to get the small supplies from nurserymen.

On estates where planting is annually conducted to a moderate extent, only from 1 to 2 acres need be occupied as nursery-ground. In this all the Oaks required may be raised from the acorn; and the forester should get a regular supply of acorns to enable him to keep up a succession of plants of the most suitable ages for transplanting into the forest-ground every year. Having such a piece of ground occupied as a nursery, the forester will be enabled to raise his Oaks to a fairly large size previous to planting them out, which is of great advantage on many properties where there is much game to contend with; and, besides this, when they are grown of a tall character the plants are not so apt to be choked by long grass and strong weeds overtopping them. To get such plants, strong well-rooted transplants of from 4 to 5 ft. high, from nurserymen would cost a very high price; whereas, when reared in the home-

nursery, they cost the proprietor comparatively little. The forester need not raise all his Oaks to a large size previous to planting them out, but only such a portion of them as may be required; yet in order to have transplants of a stronger and more bushy character than he could have from public nurseries, he will have it in his power to give them abundance of individual growing-space in the nursery-rows. In the same way the forester may raise other broad-leaved trees to a large size, as well as Pines, Larches, Spruces, Firs, &c., as the case may require; and when he has these grown to the desired strength, he can plant them out into the forest-ground to fill up blanks which may have occurred here and there in the young plantations, or to make new plantations to have an immediate effect, if that be considered desirable, or for ornamental planting of any description.

A list of ruling prices for seedlings and transplants of the different species of trees could easily be given here; but this would serve no useful end. The latest information on these points can always be procured from the catalogues of nurserymen; and prices vary considerably from time to time.

No woodland estate of moderate extent can be said to be anything like complete, with regard to the plantations, without such nursery accommodation as has just been described. Unless provided with a permanent reserve-nursery, no forester can have young trees at command in order to meet the demands of the estate, as occasion may sometimes require. Without such a reserve-nursery, no landowner can reasonably expect to have forest operations conducted properly. It would be folly to send 40 or 50 miles to a nurseryman for a few good trees to answer some particular purpose, when the same could be got more conveniently and more safely from the home-nursery; and even after sending for them, they might not be such as were expected. Difficulties of this kind are always apt to be experienced in certain situations; but, where the accommodation of a home-nursery can be fallen back upon, it is easy at all times, and at a very moderate expense, fully to meet any demands that may arise. The extent of ground to be occupied must of course be regulated according to the probable demand. If the woodlands be extensive, 2 or perhaps 3 acres may not be too much; but if they be small in extent, half an acre may perhaps be quite sufficient for all practical purposes. In making such a nursery, it should not be formed in a sheltered or low-lying part, for there the young trees are apt to be drawn up and weakly; nor should it be made upon a stiff clay land, for in such a soil young trees do not develop good bushy fibrous roots. The situation chosen should be free and open, or perhaps even somewhat exposed; whilst the soil should be light,

porous, and friable, and somewhat above the average in general quality. There the young trees will become bushy and hardy, and will also throw out numerous fibrous roots, which are always favourable to the establishment and healthy growth of young trees on their being transplanted permanently.

The preceding remarks have reference only to such establishments as are suitable for comparatively small and moderately-sized properties. On more extensive estates, say such as those on which there are from 6000 to 15,000 acres under wood, and on which there may be from 100 to 250 acres of land to plant annually, the case is altogether different. On Lord Seafield's Strathspey property, for example, there are upwards of 1,000,000 of young trees planted out yearly. There is a home-nursery of some 12 acres in extent on the estate, in which are raised by far the greater part of the young plants required. In this nursery a regular staff of nursery hands is kept, who attend to the cultivation of the young trees of the various sorts for the various stages and heights wanted. By this means the assurance is gained that every plant used is naturalised to the climate before it is planted out, which is a great matter in tree-culture; and besides, in this large nursery the proprietor is enabled to have his trees raised at a comparatively cheap rate. This, of course, arises from the extent being sufficient to support an establishment of special hands for the purpose, which could not be the case where operations are only requisite on a comparatively small scale.

Management of the Nursery.—In the above, the establishment of temporary nurseries has been recommended in connection with the woodlands on comparatively small, as well as on somewhat extensive landed properties, say on those ranging from 4000 to 15,000 acres in extent, on which the wooded tracts may perhaps extend to from 400 to 1500 acres respectively; for on such properties planting is not generally performed regularly, but only from time to time, on too small a scale to recoup the expense of keeping up a regular and permanent nursery establishment. But, on the other hand, it was recommended that on extensive hill and moorland properties, say on such as might range in extent from 30,000 to 50,000 acres, and on which it might be contemplated to plant about 400 to 500 acres annually for a series of years, regular or permanent nurseries should be established, both in order to facilitate the planting operations generally, and to have the supply of plants at the cheapest possible rate; for practical experience has shown that a regular nursery establishment is highly advantageous on extensive properties, where it is contemplated to plant on a large scale for a series of years. In the following, therefore, such a scheme of nursery culture will be sketched as may be found suitable and advantageous for planting

operations on large properties, say on such as those on which it is purposed to plant 400 acres annually for a period of fifteen or twenty years.

As the establishment of such a nursery is necessarily attended with considerable expense at the outset, the whole plan should be carefully considered and re-considered by the forester before he begins to put it into execution. If this be not attended to, considerable disappointment may often ensue.

The first point to be considered is the part of the property on which the **permanent nursery** should be situated; and this, of course, should be as near to the centre of the intended planting operations as possible. If, however, after fixing upon a certain locality for the site, it should be found that the land is of a heavy clayey nature, such a site should not be retained; on this class of land young plants, and more especially those of coniferous species, can hardly be expected to develop such stout fibrous roots as are necessary in order to ensure entire success in the establishment of the plantations. In choosing the situation, therefore, let it for preference be on a light loamy soil, even although it should lie a mile or more from the centre of the intended operations; for the advantages to be gained by the better development of the plants in such a soil will far outweigh any disadvantages with regard to transport in conveying the young trees to their permanent homes.

When an apparently suitable locality has been chosen, the next point is to see whether the situation is satisfactory in other respects —whether it be not too much exposed to cutting winds in spring or to late frosts, too much surrounded by wet and undrained lands, or too much sheltered by trees. All these points should be taken into consideration. If the site be too much exposed to cold and cutting winds in spring, the young plants would suffer such a check as to impair their health and vigour; if much surrounded by wet and undrained lands, frosts would be induced towards the end of spring and in the early part of summer, and consequently the young shoots of plants of early growth would be injured; if too much sheltered by trees, the young plants would become drawn up and of a weakly habit, and, when put out into the plantation-ground, would suffer such a check as to prevent their establishment and progress for a considerable time; if lying to the east, the effects of the morning sun in April on the plants after a night's frost would be injurious; whilst if having an aspect to the north, the soil would be cold and inactive, and the period of vegetation would be late in commencing, less energetic while it lasted, and early in terminating. In choosing the site, therefore, let the soil be rather light than otherwise; let it be neither too much exposed nor too much sheltered; let it be in rather a dry

and well-cultivated part of the estate; and let it have a southern or south-western exposure if possible, or at any rate nearer to the south and west points than to the north and east.

The author's recommendations in this matter are at direct variance with the results of practical experience in Germany, which are summarised in the following extract:[1]—

"For nurseries and seed-beds, care should especially be taken to select sites neither exposed to insolation nor to the action of drying-up winds; seeking the shady side of older crops and avoiding, so far as possible, localities exposed towards the south or west, are much to be recommended."

But it must, of course, be borne in mind that the Continental climate is much drier, or much less humid, than our insular climate; and what would be best suited for the N.W. of Scotland, might be the very worst exposure for the dry east coast of England.

When this matter has also been satisfactorily arranged, the next step is to ascertain what extent of ground will be necessary for the raising of the number of young trees that may be required. By way of example it may be supposed that the estate on which the nursery is to be established is in a part of the country suitable for rearing Oak and other hard-wooded trees on the lower portions having better soil; that it be found desirable or necessary to rear a large proportion of Pine and Larch, both as nurses for the hardwoods and for making Pine and Larch plantations, without hardwoods, on the higher parts having somewhat poorer soil; and that planting operations are to be carried on to the extent of about 400 acres annually, the species required being hardwoods of various kinds, with a large proportion of Pine and Larch both for nurses and for making purely coniferous plantations on the hilly parts of the estate. In order to ascertain the extent of ground required for the nursery, the proportion of the different species of plants that will be wanted must be calculated. In order to have a basis for calculation, it may be supposed that 200 acres are to be planted annually on the lower parts of the property with hardwoods, and with Larch as nurses; and that other 200 acres are to be planted annually on the higher portions, with an intermixture of Larch and Pine.

From this it would follow that in order to plant 200 acres annually with hardwoods, say at 12 ft. apart, about 61,000 of these would require to be produced annually, besides 484,000 Larch as nurses; and that to plant annually 200 acres of the higher grounds with Larch and Pine, say in equal proportions, and at 4 ft. apart, nearly 300,000 of each of these sorts would have to be produced to meet the annual demand.

[1] See editor's translation of Kauschinger-Fürst's *Protection of Woodlands*, 1893, p. 18.

The total number of plants requisite would therefore be:—

Hardwoods	61,000
Larch	784,000
Pine	300,000
	1,145,000

These 61,000 Oaks and other hardwooded species, which are supposed to be required yearly, will occupy a space of nursery-ground equal to about three-quarters of an acre; the 784,000 Larch plants will occupy another space equal to 5 acres; while the 300,000 Pines also required each year will occupy another space equal to 1½ acres,—thus making a total extent of nursery-ground equal to 7 acres 1 rood, which will be cleared of its crop each year successively, in order to plant 400 acres of the woodlands annually. As the Oak plants, forming the great bulk of the hardwoods, should stand for three years in the nursery-lines before they are sufficiently strong to plant out into their permanent sites, these will require to be of the respective ages of 1, 2, and 3 years; hence three regular and successive crops of hardwoods will be required, each occupying three-quarters of an acre, so that 2 acres 1 rood of the nursery-ground will be constantly occupied by the hardwoods alone.

Again, the Larch plants must stand two years in the nursery-lines before they are fit for planting out; and since, as has been stated above, about 5 acres of the nursery will be required to produce the annual number required of that species, there will, of course, be twice that number of acres necessary to maintain a regular succession of crop. Hence about 10 acres of the nursery-ground must be set apart for Larch alone.

The Pine plants must also be reckoned as standing two years in the nursery-lines before being planted out,—although this is only by way of example, for yearling seedlings or 2-year-old transplants that have stood one year in the nursery are often practically better than older schooled plants for land where simple notching can be performed safely. It was said above that 1½ acres of the nursery will be required to furnish the annual number of Pine needed, and as the plants are to stand two years in the lines, twice that extent of ground will be necessary to keep up the regular supply; hence 3 acres of the nursery-ground must be kept under Pine. The total requisite extent of nursery-ground must therefore be about 15 acres 1 rood. Besides this area, which must be kept constantly under a crop of seedlings and transplants of the various successive ages required, there will also have to be a portion equal to three-quarters of an acre regularly put under green crop each year preparatory to transplanting Oak-seedlings upon it in the following year; and another portion,

equal to 5 acres, may also require to undergo similar preparation each year for the planting of Larch upon it; while a third portion of 1½ acres may require to be similarly dealt with as a preparation for the planting of Pine upon it the year following. In addition to these specified quantities, 1 acre would have to be allowed for the sowing of Acorns, and Larch and Pine seeds; nearly half an acre for manure and compost heaps; nearly 1 acre as borders, for layering and engrafting various species of trees; and 1 acre would have to be allowed for roads, walks, &c. The whole extent of nursery-ground required for the cultivation of supplies of transplants sufficient to form 400 acres of plantation annually will therefore amount to the following:—

How Occupied.	A.	R.	P.
Area under 1, 2, and 3 years' transplanted Oak and other Hardwoods	2	1	0
" " 1 and 2 years' transplanted Larch	10	0	0
" " 1 and 2 years' transplanted Pine	3	0	0
" " green crop, preparatory for Hardwoods, Larch, and Pine	7	1	0
Allowance for sowing seeds as described.	1	0	0
" for manure and compost heaps	0	1	20
" borders for layering out, engrafting, &c., &c. . .	0	3	20
" for roads and walks, &c.	1	0	0
Total extent of nursery required	25	3	0

This may seem a large extent of nursery-ground for the rearing of 1,145,000 plants annually, and it is indeed large in proportion to that on which public nurserymen would rear the same quantity of trees; for in public nurseries the young plants are sometimes very crowded, whilst proper attention is not always paid to the rotation described. And in the present instance the object is rather to explain to foresters how a nursery should be managed in order to rear a sound and healthy stock of plants than to show how it may be carried on so as to have the planting material at the cheapest possible rate; as there is no doubt that the more healthily young plants can be reared, the cheaper is the operation of planting in the end, and the more satisfactory are its results. It is perhaps not generally known that when plants are crowded in the nursery-lines so as to take up the least possible space, and to produce the largest possible number on any given area, they are badly rooted, and many of them die when put out. Besides this evil with regard to nursery culture, it may be invariably observed that in nurseries where no attention is paid to green-cropping the land regularly previous to schooling young trees upon it, the transplants become unhealthy and stunted, and are therefore predisposed towards disease both in the nursery-beds[1] and when

[1] A list of the fungoid diseases to which plants are liable in the nursery will be found in chapter xii.

they are finally planted out,—hence one great cause of the unhealthiness to be observed in many young plantations at the present day. The above areas are therefore by no means so large as to be in reality uneconomical for the object in view,—that is to say, for the rearing of a healthy supply of transplants for annual plantations of the kinds and numbers required.

If, however, it were only intended to rear Larch and Pine of the description called 1-year transplants, a few acres less than has been stated would be quite sufficient; for in that case the plants would only remain one year in the nursery-lines, and consequently only one compartment of ground would be annually required for them, instead of two as in the scheme that has been given. But no comment need be made on this point, as every intelligent forester must be aware that, according to the number of years young trees are respectively required to be schooled in the nursery, there must be a corresponding number of compartments reckoned for them, in order to keep up a regular annual supply.

A site of, say, 26 acres having been duly selected, the next step in the order of the work is to have the soil thoroughly prepared. On the manner in which this is carried out, the ultimate prosperity of the crop in a very great measure depends. One point to attend to in the drainage of land for a nursery is to have all the drains made so as to empty into a deep well on the lowest part of the site. This is, of course, meant to supply the nursery with water, to be lifted by means of a pump; and when this has been arranged for, a large drain should be made from the well, so as to allow the overflow water to escape from it at a point about 5 ft. under the surface, and 1 ft. under the level of the nursery drains.

As soon as the land is drained it should be trenched to a depth of at least 2 ft. In doing this, all stones should be removed down to the size of a common hen's egg; for the fewer stones there are left in the preparation of nursery-ground, the better can the subsequent cultural operations be performed. In trenching, the land should be levelled as far as may be judicious, considering its general surface. To leave the levelling to be done after trenching is not economical, because some parts may necessarily have to be reduced, and would therefore be made poor and unproductive as compared with the parts that had soil added to them.

The draining and trenching operations should be performed in the late summer, in order that during November the land may be ploughed regularly all over; and in this state it should be left to be weathered or ameliorated by the action of the frosts and rains of winter. During the following spring it should be again properly ploughed and also harrowed, so as to reduce the surface to as fine a mould as possible;

and at the same time all stones that may have been left should be carefully removed. Afterwards it should be drilled up by the plough, manured with good and well-rotted dung, and sown down with turnip, mangel-wurzel, or any such crop, in order to clean the soil.

In the Editor's opinion it seems hardly economical to enrich the land with strong manure, and then plant it with agricultural produce for the express purpose of reducing the excess supplies of nutrients, and more especially of nitrogenous matter. The Continental system of collecting heaps of good soil, leaves, turf, grass, and weeds here and there in the woods, and turning them over from time to time so as to assist in their decomposition, yields a far more desirable and more humose compost for nursery purposes than stable-manure rich in salts of potash, phosphates, and nitrates. The latter, in fact, very closely resembles artificial manure in its action, concerning which the following remarks are specially applicable (Gayer, *Waldbau*, 1889, p. 326):—

"Where artificial manures are used, it must be borne in mind that they are usually rapid in action, and when used in excess are injurious to woody-fibrous plants; hence more than about 1¼ to 1½ cwt. per acre should not be added. But wherever their use is considered desirable, it is a good rule to apply them only alternately with the above-mentioned milder forms of manure (*i.e.*, humus formed of leaves), so that an application of mineral fertilizers may be succeeded in a few years by a dressing of woodland soil, leaf-mould compost, &c., and then again artificial manure, and so on."

During the summer, while this green crop is being cultivated on the proposed nursery-site, it should, if not previously fenced, be enclosed by a proper and substantial fence. This may consist of a wall, a stone dyke, a hedge, a wooden paling, or a wire fence, as the circumstances of the case may suggest; but, whatever kind of fence be erected, it must be made proof against hares and rabbits, as well as against heavy animals that may be grazed in the neighbourhood.

Up to this point the expenses connected with the nursery-site will probably amount to something like the following:—

Drainage of 26 acres of land, say at £6 per acre	£156	0	0
Trenching 26 acres, 2 ft. deep, and removing stones, say at £10 per acre	260	0	0
Sinking well and putting in pump, say	10	0	0
Building large drain to lead overflow of water from well, say	8	0	0
Ploughing 26 acres of land after trenching, say	13	0	0
Preparing 26 acres for green crop, say	30	0	0
Gathering stones, say	8	0	0
Manure, 520 loads, at 4s. per load	104	0	0
Seed for and sowing green crop, say	12	0	0
Thinning and cleaning green crop, say	15	0	0
Erecting stone wall as a fence, with wire netting on top, say 1452 yards, at 3s. 6d. per yard	254	2	0
Interest on £447, as outlying for one year, say at 5 per cent.	22	7	0
	£892	9	0
Deduct from this value of green crop, say 26 acres turnips, at £6 per acre	156	0	0
By this statement the nursery will have cost the proprietor at the end of the first year of cropping	£736	9	0

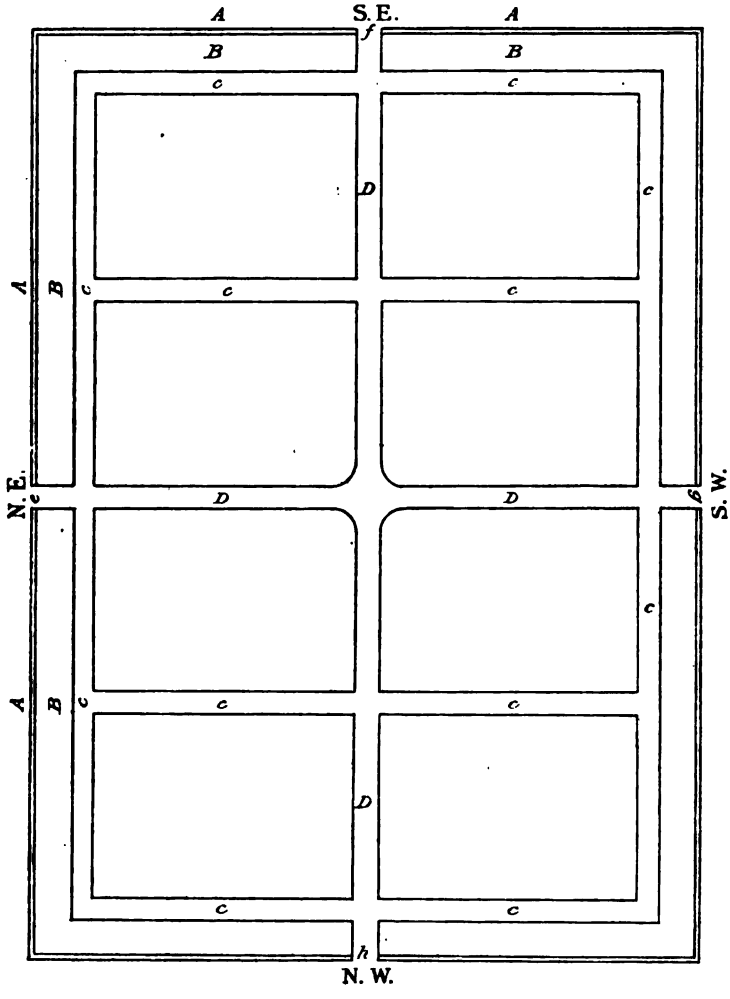
As may be seen from a comparison with the data previously given on pp. 628, 629 of vol. i., these costs are very largely in excess of what similar preparations can be done for in Germany. Even allowing for the difference in daily wages, the above rate of charges seems to the editor unnecessarily high.

For the sake of illustration it may now be supposed that the nursery preparations have arrived at the above stage in November 1894. When the green crop has been removed from the ground, it should be again ploughed regularly over, and left in the rough state, in order to have the full benefit of the winter's frost, &c., before the nursery operations are commenced in the following spring. All the roads and walks can hardly be made during the winter months, or at all events before the beginning of March, when the sowing and planting operations will have to be commenced.

Nothing has yet been said as to the form in which the nursery ought to be laid out. The nearer it is made to the form of a square, the cheaper will be the enclosing and the easier will it be to conduct the subsequent operations of lining, bedding, &c. It may, however, be made in the form of a parallelogram; but on no account should the sides be made of unequal lengths, or curved, as in such cases a great deal of trouble will be found in getting the men to keep their lines parallel with the walks and roads, whether in transplanting yearling seedlings, or in lining off the beds for sowing the seeds. And when these points are not attended to, the nursery has invariably an untidy and disorderly appearance. Besides this, as a matter of economy, it is advantageous to have all the roads and walks laid off parallel and at right angles to one another; for, when this is the case, the workmen's time is not necessarily taken up with calculations and measurements in order to arrive at certain points where other straight and parallel lines are required to agree with those on which they are presently engaged. By attention to this, much time and expense can be saved in the working of the whole. The diagram on opposite page will show how such a nursery as that proposed may be laid out with reference to the disposal of the beds, roads, and walks.

In explanation of this diagram, it may be said that the double outer line *A* represents the wall or outer fence enclosing the nursery in the form of a parallelogram, with its longest sides, each 440 yards long, lying from S.E. to N.W., and its shortest, each 286 yards, lying from N.E. to S.W., making in all an enclosure of 26 acres. The space running along the inside of the double line, and marked *B*, represents a border of 15 ft. width all round between the wall and the walk *c*; and the two cross-walks which divide each of the four great compartments into two are also marked *c*, and are all 5 ft. in breadth. The roads marked *D*, which intersect the enclosure in its

whole length and breadth, are 12 ft. wide; and in the middle of each of the sides is a gateway, as shown at *e*, *f*, *g*, and *h*. The object of this arrangement is to subdivide the whole ground into convenient portions, rectangular on all their sides, and parallel to one another, so as to facilitate operations as much as possible, and to keep one kind of tree quite separate from another. In the centre of the enclosure,



where the roads intersect, there is a large space left for the purpose of turning carts, &c., whenever it may perhaps be found necessary to do so.

In subdividing the ground by roads and walks, as shown on the diagram, the whole land embraced should first of all be made as level as the general surface will judiciously admit of; and this, of course, should be done in the act of trenching. When this has been com-

pleted, the roads from *f* to *h*, and *g* to *e*, as well as the adjoining walks marked *c*, should be made by removing the soil from them to the respective breadths specified, and to such a depth as to obtain a fairly hard base for the laying on of road material; and as the soil is removed from the roadways and walks, it should be spread equally over the borders and compartments. When the soil is removed to the depth of about 12 in., a quantity of broken stones or rough gravel should be carted and laid regularly over the walks to the thickness of at least 8 in. The next step consists in having an edging of some sort planted along the side of the roads, both in order to prevent the earth from the borders and compartments falling into them, and for the sake of neatness. Perhaps the best plant for this purpose is the common evergreen Privet (*Ligustrum vulgare*), as it is not so easily injured or thrown into bad health by being frequently trodden upon, as is the case with box and many other similar plants when they are subject to rough usage. The plants for this purpose may be of the age called **1-year cuttings**, which are generally about 12 in. high. No detailed description need here be given of the work of laying in the plants on the lines which are to form the edgings on the sides of the roads and walks, as every forester must be acquainted with such work; the plants are simply put in as a low hedge along the sides of the roads and walks, in such a regular way as to mark out distinctly the compartments on their sides.

When the edgings have been planted along the sides of all the roads and walks, the next thing will be to have them gravelled. This could not be well done before this stage; for, had the gravelling taken place before the edgings were planted, these would be injured by the operation of taking out the openings for these on each side. In finishing the walks, good hard gravel, and not soft or earthy matter, should be used, otherwise they would become soft and unserviceable in autumn and spring, and would be difficult to keep clear of weeds in summer. The upper coat of gravel should be put on 4 in. deep on the sides, and about 6 in. deep in the middle, so as to secure a slight fall from the middle to each side, to throw off rain as it falls.

At this stage the nursery-ground will be in a state fit for the reception of seeds and of the seedlings which it is intended to transplant into it. Supposing that the roads and walks have been all completed by about the 1st of February 1895, the forester should then arrange, if he has not done so previously, for seeds and young plants of the various species he intends rearing; because, in order to establish and fully utilise a nursery during the first year, it will be necessary to buy in young plants of the various sorts intended to be planted out into the plantations the following year, so as to have a stock on hand for use until plants have been raised from seed. The

number of young plants and seeds required in establishing such a nursery as above contemplated would probably be as follows:—

Plants required to be purchased during the first year:—

		£	s.	d.
Oak, 1-year seedlings	45,000	9	0	0
" 2-year "	45,000	15	0	0
" 1-year transplanted	45,000	22	10	0
Ash, 2-year seedlings	4,000	0	16	0
" 1-year transplanted	4,000	2	10	0
Elm, 2-year seedlings	4 000	1	4	0
" 1-year transplanted	4,000	2	0	0
Beech, 2-year seedlings	1,000	0	5	0
" 1-year transplanted	1,000	0	7	6
Alder, 1-year seedlings	500	0	3	6
Birch, 1-year "	500	0	2	0
Horse-Chestnut, 2-year seedlings	200	0	4	0
Sweet Chestnut, 2-year "	1,000	0	10	0
Lime-tree, transplanted 3 to 4 ft. high	200	0	4	0
Maple, Norway, transplanted, 18 in. high	1,300	1	0	0
Sycamore, 1-year seedlings	1,300	0	5	0
" 1-year transplanted	1,300	0	16	6
Walnut, 1-year seedlings	200	0	8	0
Poplar, of sorts, 1-year cuttings	1,100	0	16	0
Willow, of sorts, 1-year cuttings	1,100	0	16	0
" basket, of sorts, 1-year cuttings	200	0	3	0
Scots Pine, 1-year seedlings	300.000	30	0	0
" 1-year transplanted	300,000	90	0	0
Larch, 1-year seedlings	784,000	78	8	0
" 2-year "	784,000	294	0	0
Spruce Fir, 2-year seedlings	2,000	0	5	0
" 1-year transplanted	2,000	0	12	0
Silver Fir, 1-year "	2,000	0	12	0
Hedge plants—				
Hollies, 2-year seedlings	2,000	1	5	0
Hawthorns, 2-year seedlings	12,000	3	0	0
Total for plants	2.206,900	£557	2	6

The quantities of seeds that will require to be sown in order to secure a corresponding supply of plants for the following year will be as under:—

Oak	6 bush.	Horse-Chestnut	$\frac{1}{10}$ bush.	Thorn	1 bush.
Ash	$\frac{1}{2}$ "	Sweet Chestnut	$\frac{1}{2}$ "	Scots Pine	38 lb.
Elm	$\frac{1}{2}$ "	Maple, Norway	$\frac{1}{7}$ "	Larch	314 "
Beech	$\frac{1}{7}$ "	Sycamore	$\frac{1}{7}$ "	Spruce, Norway	$\frac{1}{4}$ "
Alder	$\frac{1}{10}$ lb.	Walnut	$\frac{1}{30}$ "	Silver Fig	4 "
Birch	$\frac{1}{30}$ bush.	Holly	$\frac{1}{7}$ "		

It may here be added that the above quantities of seed of the different species named are, generally speaking, sufficient for raising the number of plants in the previous list,—of course with the exception of the Poplars and Willows, which are raised from cuttings, and of the Lime, which is raised from layers. If foreign Larch seed be used, however, a very much smaller quantity will suffice for the raising of the plants required, as in that case even about one-third of the quantity stated may be found sufficient.

In the above purchase-list the cost of each species of plant is taken from the prices quoted in the catalogues of public nurserymen for 1893–94; but as the prices of tree-seeds vary from year to year, according to the nature of the seed-crops, it seems preferable not to state such prices as may afterwards tend more to mislead than to inform. And with the exception of the Sweet Chestnut, whose fruits ought to be imported, all the other seeds should be gathered at a merely nominal cost in good seasons in any well-wooded part of the country by young people employed by the forester.

The modes of gathering the different seeds, the time of the year at which they are ripe, and the way in which they are dealt with in sowing, have all been previously detailed under the descriptions of the different individual species of trees in the Second and Third Chapters of this work, so that it is unnecessary again to refer to these matters. It may, however, be stated in a general way, that all seeds should be gathered only while they are dry, and not when wet; otherwise they are apt to get heated, or mouldy, and to lose in germinative power. Another point to be attended to is to gather the seed only from healthy and vigorous trees, and neither from very young nor from very old or diseased individuals; because a large proportion of the seeds taken from young trees are found immature, whilst those taken from very old or from diseased trees are found to be wanting in vital power after germination. All who may wish to raise their own trees should be very careful in selecting the best seed that is available; for if not, then any given quantity of seed will not only fail to produce the proper number of plants, but at the same time the class of plants raised will be inferior in every respect to those grown from first-class seed gathered only from middle-aged trees in the fulness of health and vigour.

Thus, for example, Larch seed gathered from old and diseased trees may sometimes fail to produce 1000 plants from the pound weight; whereas, when it is got from healthy and matured trees, it ought, even in Britain, to produce about 3000 seedlings. Perhaps it is not generally known among foresters, that the best Larch seed usually collected from trees grown in this country is unfit for growing to the extent of from one-third to nearly two-thirds of the number of seeds it contains; and, as a rule, it generally follows that the greater the number of healthy seeds there are in a given weight of the seed, the more healthy and robust are the plants from it.

Approximately about 75,000 Larch seeds go to 1 lb.; and on the Continent good seed should have a germinative capacity of from about 25 to 30 per cent., *i.e.*, 1 lb. should yield at least 15,000 to 20,000 seedlings.

As Gayer remarks (*Waldbau*, 1889, p. 283):—

"Considering the circumstances of the seed-trade nowadays, one is justified in expecting the following results in experiments made for testing the quality of seed delivered

before it can be admitted to fulfil the description of 'good seed.' But the germinative percentages have only reference to well-conducted experimental tests:—

	Per Cent.		Per Cent.		Per Cent.
Scots Pine . . .	70–75	Cembran Pine . .	40–60	Hornbean	70
Black Pines. . . .	75	Oak	65	Lime	60
Weymouth Pine .	60–70	Beech	50	Elm	45
Spruce, Norway .	75–80	Sweet Chestnut .	50–65	Alder, Common .	35–40
Silver Fir . . .	40–60	Maple and Sycamore	50–60	Birch	20–25
Larch	30–40	Ash	65–70	Robinia	55–60

But, of course, when good seed comes to be sown out in the seed-beds, such high percentages can never be expected as are attainable in the case of experiments conducted under the most favourable conditions indoors; and allowance must be duly made for this shortage. Further data on this subject may be found in the editor's *British Forest Trees*, 1893, pp. 47 and 349.

For the information of those who may wish to cultivate nursery stock to a smaller or larger extent than has been here considered with regard to the raising of a sufficient number of plants for the planting up of 400 acres annually, a tabular statement is given below showing what number of plants of the various forest-trees may be expected, under ordinary conditions of the seeds as to germinative capacity in Britain, from a given quantity of each respectively:—

Species of Trees.	Time of the year when Seeds are ripe.	Quantities of Seeds.	Number of Seedlings that may be expected.	Manner of Sowing.	Depth at which Seeds should be sown.	Distance apart of Seeds when sown.	Age of transplanting from Seed-beds to Nursery-lines.
Oak . . .	November	1 bush.	6000 to 8000	In rows 18 in. apart	1 to 1½ in.	1 to every 3 sq. in.	1 year
Elm . . .	May, June	1 bush.	5000 to 7000	In rows 15 in. apart	⅛ in.	1 to every 2 sq. in.	1 year
Ash . . .	Oct., Nov.	1 bush.	12,000 to 16,000	In rows 15 in. apart	¼ to ½ in.	1 to every 3 sq. in.	1 year
Beech. . .	Oct., Nov.	1 bush.	10,000 to 12,000	In rows 15 in. apart	½ to ¾ in.	1 to every 2 sq. in.	2 years
Alder. . .	Oct., Nov.	1 lb. of clean seed	5000	In beds	⅛ to ¼ in.	1 to the sq. in.	1 year
Birch . . .	October	1 bush. of clean seed	15,000 to 18,000	In beds	⅛ in.	200 to the sq. ft.	1 year
Horse-Chestnut	October	1 bush.	2000 to 3000	In rows 18 in. apart	1½ to 2 in.	1 to every 4 sq. in.	1 year
Sweet-Chestnut	Mostly imported	1 bush.	3000	In rows 18 in. apart	1½ to 2 in.	1 to every 4 sq. in.	1 year
Norway Maple	October	1 bush.	10,000 to 15,000	In rows 15 in. apart	½ to ¾ in.	1 to every 3 sq. in.	1 year
Sycamore . .	October	1 bush.	10,000 to 15,000	In rows 15 in. apart	½ to ¾ in.	1 to every 4 sq. in.	1 year
Walnut . .	October	1 bush.	4000 to 6000	In rows 18 in. apart	1½ to 2 in.	1 to every 4 sq. in.	1 year
Scots Pine .	Nov., Dec.	1 lb.	7000 to 10,000	In beds	⅛ to ¼ in.	2 to the sq. in.	1 year
Larch . .	November	1 lb. of home seed	2000 to 3000	In beds	⅛ to ¼ in.	2 to the sq. in.	1 year
Norway Spruce	November	1 lb.	8000 to 10,000	In beds	⅛ to ¼ in.	2 to the sq. in.	2 years
Silver Fir .	November	1 lb.	About 500	In beds	¼ to ½ in.	2 to the sq. in.	2 years
Pinaster . .	Mostly imported	1 lb.	500 to 800	In beds	½ to ¾ in.	1 to the sq. in.	1 year
Hawthorn. .	November	1 bush. of clean seed	15,000 to 18,000	In beds	¼ to ½ in.	1 to the sq. in.	2 years
Holly . .	November	1 bush. of clean seed	15,000 to 20,000	In beds	¼ to ½ in.	1 to the sq. in.	2 years

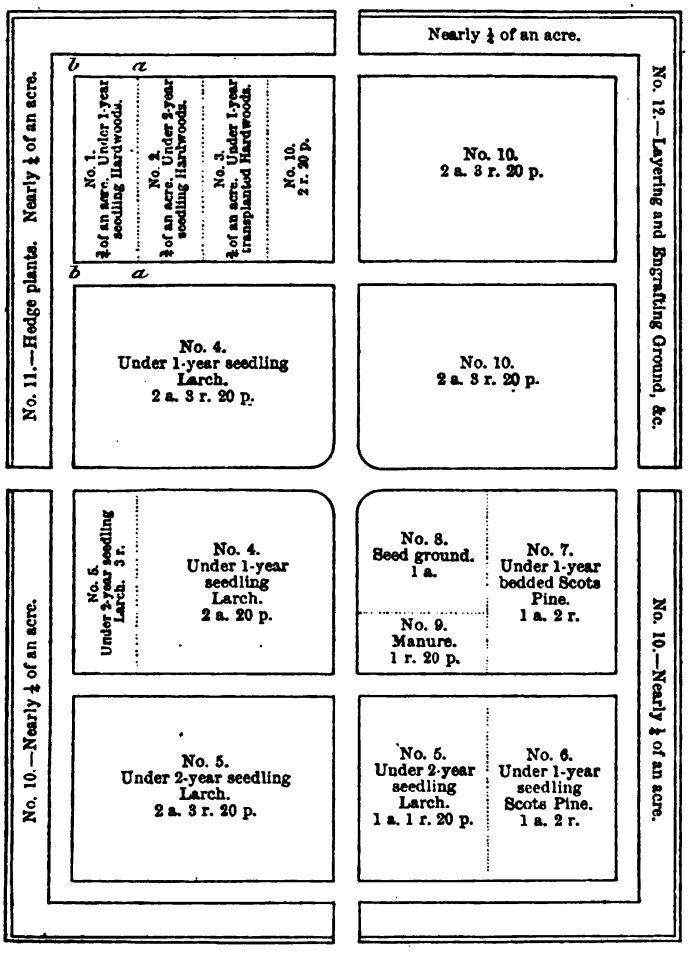
The numbers of plants stated in the above table as being produced from the respective quantities of seeds are not always obtained; for germination depends not only upon the quality of the seed used, but also on the state of the ground in which it is sown, and on whether the work of sowing and covering the seed be properly performed or not. If the seed be sown while the land is wet, or if it be covered too deeply, equally good results will not be obtained, as the above averages are only founded on practical experience in Britain under favourable conditions.

In ordinary seasons, the beginning of February will generally suit either for the sowing of such seeds as do not keep well over the winter, or for the planting of the broad-leaved species of trees. The latter should, when bought and delivered, be at once **sheughed** and kept in readiness on the ground for planting out along the lines. At the same time the Oak, Beech, Horse-Chestnut, Norway Maple, and Sycamore seeds gathered in the previous autumn should all be sown as early as possible after they are collected. When all these are held in readiness for planting and sowing as soon as the weather is open and favourable, and the ground as dry as may be expected at the season, nursery operations should be commenced without delay, as illustrated by the diagram on the opposite page.

From this diagram it will be seen at a glance how the different crops may be apportioned over the ground. Compartments Nos. 1, 2, and 3, each including three-fourths of an acre, are laid off for the three different ages of Oak and other broad-leaved trees. The two compartments, Nos. 4, 4, respectively containing 2 acres 3 roods 20 poles and 2 acres 20 poles, or 5 acres in all, are set apart for the planting of the 1-year seedling Larch plants. The three compartments, Nos. 5, 5, 5, respectively containing 2 acres 3 roods 20 poles, 1 acre 1 rood 20 poles, and 3 roods, or 5 acres in all, are laid off for the 2-year seedling transplants of Larch. Compartment No. 6, containing 1 acre 2 roods, is set apart for the planting of the 1-year seedling Scotch Pine; and No. 7, containing also 1 acre 2 roods, for the older class of 2-year seedling Scotch Pine transplants. Compartments Nos. 8 and 9, containing 1 acre, and 1 rood 20 poles, respectively, are laid off, as indicated in the diagram, for the sowing of the tree-seeds, and for manure, &c. Finally, the three compartments, Nos. 10, 10, 10, and the two borders, Nos. 10, 10, containing in all about 7 acres, are kept ready for being put under some temporary crop during the ensuing summer, and being lined with young transplants in regular rotation during the following spring; whilst the borders, Nos. 11 and 12, extending in all to half an acre, are laid off under hedge plants, and for purposes of layering.

Nursery Staff and Implements.—Before entering into details

as to sowing and planting, it may be well to state that the forester should have engaged for the work some eight or ten expert men, a preference being given, if such are procurable, to those who have had some experience in nursery operations. Even two or three men who have been some time in a public nursery, and who may therefore be able to teach the others how to operate along with them, are an



acquisition among inexperienced hands. He must also provide a good spade for each man employed, two large wooden harrow-rakes about 24 in. long in the head, as used by nurserymen, two middling-sized iron rakes about 18 in. in the head, and two smaller rakes of 12 in. in the head, which are all required in bringing the earth to a fine mould. The other articles required before the work commences include two good garden-lines on reels, a 12-ft. measuring-rod, dis-

tinctly marked in feet and inches along all its length, and measuring-sticks of about 2 ft. long, marked in inches, for setting out the parallel lines on the nursery-beds. When such a properly-equipped staff of workmen is collected, the actual operations may commence.

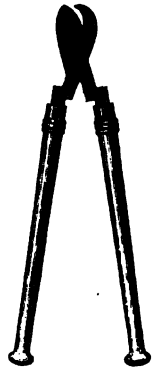
Bedding of Transplants.—As indicated in the diagram, compartment No. 1 is proposed to be planted with the 1-year seedling hardwoods. The only plants, therefore, which are specially intended for this compartment are the 45,000 1-year seedling Oak, together with the 1300 Sycamore, and the 200 Walnut, for these are the only 1-year seedling hardwoods specified. But, as three-fourths of an acre are more than is necessary for the planting out of these hardwoods, the 4000 Spruce and the 2000 Silver Firs may easily be planted out in the same compartment, in order to fill up the whole of it with plants which may be ready for ultimate removal along with the Oak. This arrangement having been fixed on, and the plants having been all properly sheughed at one end of the compartment, the workmen will next stretch their line from one walk to the other, as shown on the diagram by the dotted line *a a*, in order to form a distinct boundary for the compartment. When the line has been marked off to the desired breadth, so as to lay off the extent of ground wanted, as from *b* to *a*, and has been put down exactly at right angles with the two walks between which it runs, the earth should be properly levelled and firmed all along the run of the line, to the breadth of about 9 in. on that side on which the work is to be performed, and 3 in. on the opposite one. The men should then be instructed to take out an opening, say 4 in. deep, along the whole length of the line, exact to its run, and upon that side of it on which compartment No. 2 lies. In doing this, the cut along the run of the line should be made to slope a little outwards; and as the earth is removed in making the opening, it should be thrown upon compartment No. 2. This opening will now form the boundary of compartment No. 1, and will afterwards form also the edge of a temporary walk which will be necessary between compartments 1 and 2. The line is next lifted, and again laid down about 8 in. inwards from where it previously lay, or just where the boundary of the compartment begins. In adjusting the line, care should be taken to lay it down exactly parallel to its previous position, but 8 in. inside of the compartment now to be operated on; then another opening should be made along its run, in every respect similar to the last, but of course sloping in the opposite direction or towards No. 1. When these two openings have been made, a level and smooth strip, 8 in. in breadth, will run between the two stalks from *a* to *a*, which will not only form a distinct boundary to the compartment, but also prove a guide to the workmen in keeping the whole ground level as the work of planting proceeds.

The men should next with their spades level the earth all along the back of the Privet hedges forming the edging between the walks and the other three sides of this compartment. This may be done to the extent of 28 in. in breadth all round, and should be very easily accomplished, as of course the ground along the lines of the hedges would be properly levelled when these were planted. The line should then be stretched along the backs of the hedges, about 24 in. in from them, and an opening taken out along its run, with the slope inwards. The compartment will now be surrounded by a level belt or strip, which will be a simple guide for the workmen in keeping the land level during the operation of planting.

The next work will be to have an opening taken out with the spade along the end of the compartment opposite to that where the plants have been sheughed; and in doing this it should of course be taken out along the inside of the level edging just completed, but a few inches from it, in order that its smooth edge may not be disturbed by the spades. As this opening is made, the earth from it should be put into wheelbarrows and removed to the opposite end of the compartment, and there laid carefully down along its whole length, in such a way as to interfere neither with the other smooth edging made close to the back of the hedge, nor with the plants that were sheughed, but so that it may be in a line between the two.

When the smooth edging, made 24 in. inwards from the hedge, has been completed along the end of the compartment, and the opening has been taken out along the inside of it to the depth of about 5 or 6 in., the workmen will prepare it for the first line or row of young trees, by making it as nearly as possible perpendicular; for if its side were left in a sloping position, the plants could not be easily set upright against it. The young hardwood plants should then be brought forward, taking the Oak first, for example. They should not be brought in large numbers, but only just as many at one time as will be required for three or four rows. As soon as they are brought from the sheugh to the ground in which they are to be planted, the foreman of the workmen should sort them evenly in his hand, and cut off the extreme points of the roots with the pruning-shears (Fig. 229) in order to cause them to become more fibrous. He will then lay them down evenly and flat on the ground, and spread a little earth over their roots, in order to prevent the wind or drought from drying them; for the more carefully the plants are dealt with in this respect, the more likely are they to succeed well afterwards. The forester must in the meantime see that the length of the row to be

Fig. 229.



planted is properly apportioned to the number of men he may have engaged in the work. Say, for example, that there are eight men employed, and that the length of the row is 48 yards, it therefore follows that each man will have to plant 6 yards of each line as his portion; hence the forester should accordingly measure off the ground for them, and make each man, before he commences, put up wooden pegs both in the levelled border where he is to begin, at right angles with the line of the rows, and also at the point where his portion terminates. Each man next takes in his hands as many plants as will be sufficient to plant his portion of the row, here supposed to be 6 yards. And as the plants are to be put in the rows at 4 in. apart, the men will each have to lift 54 plants for one row. Each having supplied himself with plants, the forester should instruct every one separately how to lay them down on the top of the smooth edge of the opening, regularly in small quantities, say in tens, and at regular distances apart, in order to be the more conveniently handled and got at while planting them. When the plants are all arranged and laid out, each man will take his position on the left-hand side of the portion of the row he is to plant, and kneel down on his left knee, with his left side towards the newly-cut edging. In this position he takes a plant in his left hand, laying hold of it between forefinger and thumb about 1 in. above the part forming the junction between the stem and the root proper; and this part of the stem he places exactly against the angle on which the line rested when the opening was made for the roots of the plants, inserting these at the extreme left-hand side of his portion to be planted, and keeping the second joint of his forefinger flat on the angle, and his thumb downwards. Whilst the plant is thus held in his left hand, with the right hand he draws together a quantity of the finest of the loose earth lying in the opening before him, sufficient to cover the roots and to keep the plant in its place. This he should lay carefully upon the roots, giving it a slight pressure with the right hand to prevent its getting detached from the smooth wall of earth and thereby allowing the plant to fall from its place. In the same manner, all the young plants should be inserted 4 in. apart all along the line; and when these are all put in their places, the men should with their spades add a little more of the finest of the earth to that already laid on the roots with the hand. But this is only requisite to such an extent as to secure the roots being covered regularly with about 3 in. of soil, after which the whole line of plants should have the loose earth gently firmed over the roots by a slight pressure with the foot. The men should next dig backwards by narrow spits, laying the earth on and towards the roots of the plants till they are sufficiently covered, and till the turned-up soil is about 1 ft. in breadth between the plants and the

opening, when the final adjustment of the plants should take place along all the length of the line. This is done by each man examining his portion, taking hold of such of the plants as seem to lie to one side, and setting them upright by a slight pressure with the foot. After each man is satisfied that his plants are rightly bedded, he should commence to dig the earth full up to the general level, and continue doing this till he has fully 2 ft. in breadth of the dug ground between the row of plants and the opening under his feet, when another edging should be made to receive another line of the young trees.

At this stage of the work the 24-in. measuring-sticks will be required for laying-off the rows at regular distances and parallel to one another. One of these should be given to the man on the extreme left, and another to the man on the right of the row, as both will have to measure the distance and adjust the line as each new edging is made. In using the sticks, each man places one end of his stick at the terminal plant of the line just planted, and marks off 2 ft. on the edging; then the line is stretched by the two end men, so as to prepare the edging for a new row. This is done by stretching the line tightly between the levelled edgings running along the sides of the compartment, and afterwards levelling and beating the earth on the run of the line as before. An opening is taken out along the run of the newly-laid line to the same depth as previously, and the planting of the second row of seedlings is performed in every respect similarly to that of the first.

All the plants intended to be planted in compartment No. 1 should be dealt with in the same way till the whole task is finished. Care should be taken, as the work proceeds, to see that the lines or rows are kept at right angles with the sides of the compartment, and perfectly parallel to one another; for if they be allowed to run diagonally, the nursery would have an untidy appearance.

When the 1-year seedling plants are all put in, the Silver Fir and Spruce, which are of slow growth when young, may be planted along with them, the same mode of operation being continued from where the planting of the hardwoods terminates. But as these two species of *conifers* are not of such rapid initial development as the hardwoods during the three years they are to stand in the nursery, they do not require so much growing-space. The distance between the rows or the lines may therefore be 10 to 12 in., while that between the plants forming the lines may be 3 to 4 in.

The distance between the rows, and between the individual plants in the rows, depends on the size of the seedlings, on their natural vigour, and on their rate of growth, as well as on the length of time they are intended to remain in the nursery. Thus Gayer remarks (*op. cit.*, p. 337) that for 1- and

2-year-old seedlings of Spruce, Scots Pine, and Silver Fir, which are intended to be schooled for two to three years, a distance of 6 to 8 in. between the lines, and of 4 to 6 in. between the individual plants in the rows, is sufficient; but that it should not be less if the soil is to be turned up from time to time. For Larch and for quick-growing broad-leaved species, however, the distances should be greater.

It may also be remarked, that although 2-year seedlings and 1-year transplants will both be required, still they should all have the same growing-space allowed them, as they can easily be thinned by the lifting of alternate plants when the younger class is wanted for planting. In planting Firs in nursery rows, care should be taken not to set them too deeply in the earth, as they do not usually thrive well when this is the case. In planting them, therefore, the foreman should be particular to see that the men put them in only to the depth they have stood in the seed-bed or in the former lines.

When compartment No. 1 has been completely planted up, a move is made to compartment No. 2, in which, as indicated on the diagram, it is proposed to plant all the 2-year seedling hardwoods, to the following numbers :—

Oak, 2-year seedlings	45,000
Ash, " "	4,000
Elm, " "	4,000
Beech, " "	1,000
Alder, " "	500
Birch, " "	500
Horse-Chestnut,	200
Spanish Chestnut,	1,000
Total,	56,200

There are thus 56,200 2-year seedlings of eight different species to bed out there. In preparing this compartment for planting, its boundaries should first be properly levelled and marked off, as described for No. 1, so as to leave an alley or walk of 2 ft. in breadth between them. The plants should then be brought forward and sheughed at one end of it, and the opening taken out at the other preparative to planting; and they should all have the points of their roots removed, as described with regard to the 1-year seedlings in compartment No. 1. The work of planting them in the rows should then be proceeded with as has been described with reference to the latter, except that the 2-year seedling plants will necessarily have to be put deeper into the earth, as their roots are proportionately longer.

When the Oaks have been planted, Ash, Elm, Beech, Alder, and Spanish Chestnut may all be made to follow in the order that is preferred, each sort being, of course, kept separate from the other.

It should suffice if the rows are kept 1 ft. apart, and the plants put out at 4 in. distance.

As the Horse-Chestnut generally grows stronger than most other broad-leaved species while young, they should be kept about 6 in. apart in the rows; but they need not be planted in wider rows than any of the others.

As Birch is of comparatively slow growth at first, it may be planted somewhat closer than the other deciduous species.

In bedding the 2-year seedlings, greater care is necessary to have them made properly firm in the earth than in the case of smaller plants, so that attention must be given to ensure this; for if not, then many plants are sure to die off. In the case of most trees, 2-year seedlings are always more difficult to transplant than 1-year seedlings, as they have fewer and more weakly fibrous roots in comparison with their size. Any mention at all of 2-year seedlings as transplants is merely made here in order to have plants for use as early as possible. In any nursery established for some years the different classes of transplants are usually made entirely with yearling seedlings.

As it was arranged that, on compartment No. 3, 1-year transplanted broad-leaved trees should be bedded, there will be the following number of plants to put out:—

Oak, 1-year transplanted	45,000
Ash, " "	4,000
Elm, " "	4,000
Beech, " "	1,000
Maple, Norway, "	1,300
Sycamore, " "	1,300
Poplar, " "	1,100
Willow, " "	1,300
Total	59,000

In bedding these different species, the boundaries of the compartment must be first marked off as previously described, and the various kinds put out each by itself, as, for example, in the order in which they are named, the Oak being all bedded first, and the Willows last. Care should be taken to plant this class proportionately deeper than either of the two already referred to, as their root-systems are already more largely developed. The only rule that can safely be given as regards this matter is that all the root-system of each plant should be properly covered, together with not more than an inch of the stem; for, whether in the nursery or in the open forest, deep planting is very apt to lead to wilting of the plants.

Next come the 784,000 1-year seedling Larch, which, according to the previously arranged scheme, are to be planted in the two

compartments numbered 4, 4, and extending to 5 acres. The whole of the two compartments allotted to them, after deducting allowance for alleys, will suffice to permit of the rows being 16 in. apart, if the plants be inserted nearly 2½ in. distant in the lines. As, however, it is not convenient (for weeding, &c.) to plant such large compartments from side to side all in one piece, it will be found advantageous to have these compartments subdivided. This can be easily accomplished by running alleys across from hedge to hedge on each side, and in lines exactly corresponding to the alleys dividing the compartments supposed to be planted with hardwoods. Subdivision of large compartments is necessary, not only for convenience during the time of planting, but also while weeding and cleaning the ground. In laying off these alleys, they should be made 24 in. broad, levelled on the sides, and properly edged off, as previously recommended for similar work in compartments Nos. 1, 2, and 3. And the ground behind the hedges surrounding the compartments should also be levelled and edged off in a neat way, for the guidance of the men in planting. When subdivision has taken place, the compartments will now be in readiness for receiving the plants.

It must, of course, be understood by the forester that, in purchasing seedling Larch for nursery-stock, only first-rate plants should be bought, and not weaklings; as their after success will entirely depend upon whether the plants are of a weakly or a strong constitution. Really good 1-year old Larch seedlings should be neither tall nor drawn up, but stout and firm of stem; on the average they should not be much over 3 in. high above the root, with the buds large, prominent, and well-formed. Many are in the habit of choosing Larch seedlings more for their height than for any other quality; but this is a great mistake, as they may perhaps be tall owing to being crowded in the beds or forced with manure. Weakly plants may be drawn up tall so as to appear to have made great growth, while in reality they are soft and badly ripened in the wood, small budded, and of inferior description; whereas plants of a really strong natural constitution will, under all circumstances, be firm in the texture of their wood, and should exhibit large and prominent buds.

The best description of plants having been obtained and laid in by the roots at the ends of the several subdivisions of the compartments opposite those at which it is intended to commence planting, the work should be at once proceeded with as previously directed in the case of the 1-year seedling hardwoods, except that no pruning of the roots of the Larch is necessary.

As work is completed in each sub-compartment, the ground should present a uniform level surface from side to side. If the earth be rough and difficult to reduce to a fine mould, all the more time and

care should be bestowed on the work; for unless, in nursery-beds, the earth be finely pulverised, the plants are more liable than otherwise to suffer from the effects of drought.

When the planting of the 1-year seedling Larch is finished, the next in order is the 2-year Larch, which it is proposed to bed out on the three portions numbered 5, 5, 5. The subdivision of these by alleys for convenience in planting and tending, the levelling of the boundaries, and the formation of edgings along them, are all carried out exactly as in the previous case of compartment No. 4. But this class of plants should be allowed somewhat more growing-space than the younger seedlings; they may therefore be planted 3 in. apart in the rows, and may perhaps even have 18 in. between the lines. The plants should be very carefully chosen, as when Larch or Pine have stood two years in beds they are generally drawn up and weakly both in stem and roots. Great care should, therefore, be exercised in getting them from beds that have not been over-crowded; and if, at the time of planting, their roots be mulched in a thick mixture of earthy loam and water, this will tend to preserve them against the effects of drought. Other points to be attended to in the planting of 2-year seedlings are, that their roots should be carefully embedded in the finest and richest portions of the soil, and that, as each row is planted, all the finer particles of the earth should be carefully applied so as to fill up all interstices on the surface above the roots, and then firmly beaten in with the back of a spade, to prevent the soil from becoming dry.

Next come the 300,000 1-year seedling Scots Pine, proposed to be planted in compartment No. 6, extending to 1½ acres. This may be accomplished, after making deductions for alleys in subdividing the compartment, by planting them in rows about 14 in. apart, and placing them 2 in. apart in the lines. This is, however, a greater distance or a larger individual growing-space than is requisite for such small plants. With respect to the laying off and planting of the subdivisions, the details given regarding the 1-year Larch are also in every respect applicable here.

Compartment No. 7 is proposed to be planted with the 300,000 1-year-bedded Scots Pine, *i.e.*, 1-year seedlings that have been closely transplanted for one year. These should be dealt with similarly to the 1-year seedlings; they require, however, a little more room than those.

It has been stated above that the work of planting should be begun not later than the 1st of February; but this does not mean that this particular month is the best time for performing the work. Nursery operations may be begun in the month of November, and continued throughout the winter while the weather is open and

favourable, even till the middle, or sometimes the end of May. But in the case of a nursery under formation,—as the whole of the ground is supposed to have been under green crop, and only newly cleared of it, and as the roads and walks have to be laid off and made, as well as the edgings along the sides of them,—before the work of planting can be properly commenced in the compartments, sufficient time must be allowed for the proper performance of those operations. The latter works can be carried out during the months of November, December, and January, so as to permit of the work of planting beginning by the 1st of February at latest. In nurseries that are already established in proper working order, the transplanting of the deciduous species into the nursery immediately can easily take place any time after they have ripened their shoots in autumn, *i.e.*, any time after the beginning of November; whilst the work of planting out the coniferous species should be attended to in the spring months. But upon no account should bedding operations be performed in frosty weather, as the very tender fibres of the young plants are apt to be injured, and death may often ensue in consequence.

The physiological aspect of the case has previously been mentioned with regard to planting out in the open (see chapter on *Planting*). The least disturbance in the organism is occasioned in spring, when the plant has imbibed a comparatively large supply of moisture, and the time has arrived when the "flow of sap" is about to commence; hence that is the most favourable time for transplanting.

Any forester who has the management of a nursery should attend to the planting of small seedlings while the weather is open and favourable, or even wet, as their fibres are very tender and soft, and therefore easily injured by sharp drying winds. There is not, however, so much danger in this respect in the winter as in the spring months. It sometimes happens that when there is a large extent of woodland to plant in the autumn, all hands are called off for this purpose; and more especially when the season happens to be generally unfavourable for planting, so that the work cannot be done continuously. In such cases nursery work is unavoidably neglected for a time, in order to push on with planting in the enclosures; hence it often happens that nursery work is for the most part performed in the spring months, after the plantations for the season have been formed. In all operations of planting or transplanting, whenever there is any inclination to drought, the roots of all young plants should be mulched or dipped into a loamy mixture immediately on their being lifted from the beds, and before they are put into the sheugh. This prevents the rootlets from becoming dry, and keeps them safe till planted.

One-year seedlings should not be planted till the spring season

is far advanced, owing to the risk from frost; for if a strong frost should set in immediately after yearling seedlings have been transplanted, they are likely to be very much injured by being lifted with the soil and then thrown down when the earth sinks in thawing. A good general rule is to transplant all large plants in the autumn and early part of winter; 2-year seedlings, if there should be occasion to use any, from the middle of February to the 1st of March; 1-year seedlings of deciduous species from the 1st of March to the 1st of April; and all yearling seedling evergreen conifers chiefly during April, and up to the middle of May if necessary.

Sowing in Nurseries.[1]—The next subject to be referred to in connection with the nursery is the sowing of the tree-seeds, which it was proposed to sow in compartment No. 8, extending to 1 acre. Details with regard to the various kinds of tree-seeds have previously been given under each individual species of tree in Chapters II. and III., and again in condensed tabular form on p. 109, both of which should be consulted in connection with the following notes relative to the different kinds of seeds.

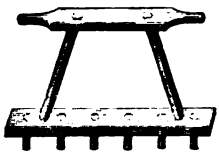
Oak.—Care should be taken to see that the acorns are of such quality as will ensure a healthy and vigorous crop of seedlings. If the seed be of an inferior description, the plants will be weakly in consequence. The larger the acorns, the stronger and the more healthy are the plants produced from them; and therefore the better is the class of timber-trees also. The acorns should preferably be collected from trees that have at least arrived at middle age, that are still healthy in all their parts, and that have not yet begun to exhibit any signs of senile decay. Seed gathered from comparatively young trees, although seemingly of fair size, is wanting in that degree of vitality which is necessary to produce strong healthy plants; and seed gathered from very old trees, especially if in a state of decay, is small, and therefore unfit to produce vigorous plants. Acorns of a proper description having been collected in dry weather some time about the end of October or the beginning of November, and of the quantity required, say 6 bushels, they should be carried home in open baskets, or in bags if they are to be conveyed a considerable distance, and stored thinly on the floor of a loft till the desired quantity is secured.[2] While the acorns are being gathered, the piece of ground should be prepared on which it is intended they should be sown. This preparation consists in digging up the ground thoroughly, and using the large rake freely, in order to reduce the earth to a finer mould than can be done by the spade alone. The sowing should then take place in parallel rows, 15

[1] See also the remarks on pp. 107–110.

[2] When it is necessary to store the acorns over winter, the Continental method is to be recommended (see Chapter II. p. 92).

in. apart, centre from centre. The line having been stretched from side to side of the compartment, where the first row is intended to be sown, the acorns, held in an apron, are dibbled in about 1 to every 3 square in., keeping the rows of seeds on each side of the line, and from 5 to 6 in. broad, taking the run of the line as the middle of the row. When the first row has thus been sown, the line is removed to 15 in. distant from, but parallel to, its first position; and in the same way the sowing is continued in lines till all the ground has been sown. A soil-covering of good mould should then be given to the depth of 1 to 1½ in., by means of lifting the soil slightly with the spade between the rows of acorns. It is preferable to give this soil-covering with the spade, as it is then more equal than if done with the rake or the hoe; for when the latter are used, many of the seeds are displaced, so as to cause them to come up irregularly. When the soil-covering has been given, however, a fine rake should be used to smooth the earth, care being taken not to disturb the seed by raking deeply. By sowing the acorns on the surface, and by taking out the soil-covering from between the rows, the seeds are kept on a dry bed all winter, germinate well in the following year, and ripen their wood thoroughly before the season closes in autumn. The very opposite of this is generally the case with regard to plants raised from seed sown in drills.

Fig. 230.



Acorn-dibbler.

The following is the Hanoverian method (Burckhardt's *Säen und Pflanzen*, 1893, p. 77):—

"The seed-rills, which are made with the hoe to a breadth of 3 to 4 in. along the line, should be 18 in. apart at the very most, and ought to be closer if early transplanting be intended. Instead of strewing the acorns in these rills, they should be laid in the rows at regular intervals of about 3 in. apart, and the rows can be made closer together. The acorn-dibbler previously mentioned (Fig. 230) can be advantageously utilised in dibbling in the seed in lines about 1 ft. apart."

Ash.—The keys of the Ash having been gathered from healthy trees in the month of October, the seeds should be mixed with sand for rotting their coats, and treated as previously recommended (Vol. I. p. 128). After the seed has lain a sufficient time to have its coat rotted, the mode of sowing it is in every respect the same as that just recommended for acorns, except that the Ash is generally sown in March in rows about 12 in. apart, and that the soil-covering should only be from ¼ to ½ an inch of earth.

Elm.—The Elm generally ripens its fruits in June, and the seed must be collected from the trees before it falls. It is sown in lines from 10 to 12 in. apart, and lightly mixed up with the earth, so as only to have a covering of about ⅛th of an inch of soil. In sowing

Elm seed, it must be borne in mind that the seeds are very soft, tender, and easily injured. The soil in which they are sown, and with which they are covered, should be made as fine as possible; and the sowing should take place on a dry day, when the earth has no tendency to adhere to the seeds, as this tends to rot them.

Beech.—The seed of standard Beech ripens freely in most seasons during October and November. It is easily gathered as the beech-nuts fall from the trees, when it should be mixed with sand to be preserved till the sowing out in March. It should be sown thickly in lines from 8 to 10 in. apart, and about 2 in. in breadth and depth, and should receive a covering of soil of ½ to ¾ of an inch of earth. This is a very hardy and free-growing seed; but the plants are always small at first, and therefore they require to stand two years before they are fit to be put out into the nursery rows.

Alder.—The Alder ripens its fruits in October and November, and sheds the seed early in spring, when it should be collected and at once sown in March. The seeds should be sown thickly on finely prepared earth, like the Elm, in beds about 4 ft. broad; it requires a soil covering of only ⅛ to ¼ of an inch of earth. When only small quantities of Alder, Birch, and Elm seed are to be sown, it is advantageous to raise all three species of seedlings on one bed, as they require very nearly the same treatment as to soil-covering and manipulation.

Birch.—The sowing of Birch-seed is carried out in the same manner as specified for Elm and Alder. As the seed is not only very small, but also has a lower germinative capacity than Elm or Alder, it should be sown rather more thickly than either of these species. Care must be taken to give it only the very slightest of soil-covering, as the seed rots or fails to germinate if too deeply covered. In short, the slightest covering of the very finest earth is sufficient for the seeds. This requires to be put on very equally all over, and should not be disturbed with the rake, but only have a gentle smooth down with the back of the spade, or by having a light roller passed over it.

Horse-Chestnut, Sweet Chestnut, and Walnut are to be sown in every respect as has been described with reference to the acorns, —except that the larger the seeds, the greater should be the depth of soil-covering.

Unless the seeds of the Horse-Chestnut be sown with the smooth side upwards and the scar below, the seedlings are apt to be weakly and to have deformed roots (see editor's *British Forest Trees*, 1893, p. 309).

Maples.—The Norway Maple and the Sycamore are also sown on the surface of the ground in rows 10 to 12 in. apart, and at the rate

of one seed to the 3 sq. in.; but they are only covered to the depth of ½ to ¾ of an inch.

Holly or Holm.—The seed of the Holly or Holm, after having been rotted in a heap mixed with sand, or any fine earth, for a period of fifteen or sixteen months, should be sown in beds in the month of March. The surface of the bed should be smoothed with the back of the spade before the seeds are laid upon it; after they have been sown they should be covered with about half an inch of the earth from the alleys. The earth should be made moderately fine for the covering of this class of seeds, and should be laid on equally and evenly; and it is an improvement to pass a light roller over the bed when finished, in order to prevent too sudden drying of the earth on the surface. In sowing the Holly-seeds, as they are mixed with sand and cannot well be separated, the better way is to sow both together. In estimating the quantity of seed, an allowance must then at the same time be made for the sand. The seed is apt to lie over, *i.e.*, seldom all germinates in one year; but the seedlings continue to come up for two successive years.

Hawthorn or Quick.—The method of sowing the haws or seeds of the Hawthorn is in every respect similar to what has been recommended for the Holly.

Conifers.—In sowing the seeds of the different Pines, Spruces, and Firs, special care should be taken only to do this in dry weather; for if the work be performed when particles of wet earth readily adhere to the seed, its germinative capacity is apt to be interfered with. Sowing operations should therefore only be undertaken after some days of dry weather, if possible, when the rake can be used freely without the soil adhering to it.

Those who cultivate from seed the coniferous trees of recent introduction into Britain are aware that in early summer the drying effects of the sun often prevents the greater part of the seed from germinating; hence the seed-beds must be protected from the direct rays of the sun until the young plants have appeared above ground, and are sufficiently vigorous to draw nourishment from the soil. Various means are resorted to for the purpose of shading the surface of the seed-beds from the direct rays of the sun, such as stretching mats, or thin cloth, or evergreen branches over them; but mats and thin cloth throw too much shade on the surface of the beds, and cause the young plants to come up weakly, while evergreen branches soon wither under the sun's heat, and in a short time become almost useless as a protection. A better method is to erect a framework of boards, about 9 in. broad and ¾ in. thick, setting these on their edges in a regular line along both sides of each of the beds, and supporting them in their places, wherever they meet, by strong pins

driven into the ground, so as to form a kind of box on each bed. Thin laths are next placed on them, right across the beds, each 3 in. apart from the other, and these are nailed at each end on the upper edges of the boards. These laths should be about 3 in. broad only, and cut to suit the breadth of the beds, so that the open spaces and the laths will be of equal breadth; this will ensure such a checkered light and shade over the surface of the beds as may be most favourable to the germination of the seeds and the production of healthy and strong plants. The frames may be allowed to remain till the plants are fairly strong, and have begun to form good roots, when they should be gradually removed by taking off each alternate lath at first, and then latter on the whole of the framework.

As it is desirable to pulverise the soil as a preparation for the sowing of the small seeds of Scots Pine, Spruce, and Larch, three different sizes of garden-rakes should be used for this purpose, and should be kept in operation as the men turn over the ground with their spades. The men who are employed to dig begin each at the same end of the opening, and continue digging to the other end; and they proceed in a regular manner one after the other, each turning over to the other side of the opening before him about 5 in. of the solid ground on which he stands. These are followed, first by a man with what is termed the large harrow-rake, having teeth 4 in. long and 3 in. apart, with which the earth is thoroughly broken as it is turned over by the men with the spades. The harrow-rake man is followed by another with a medium-sized rake, having teeth 3 in. long and 2 in. apart, with which the earth already raked is worked up again; and a third man follows the other two with a small rake, having teeth about 1 in. apart and 1½ in. long. The four men proceed digging, raking, and re-raking in this way, one party following the other from side to side, till all the ground has been thoroughly prepared. As each raker proceeds, he clears the ground from all stones, &c., that he can gather with his rake, and draws them down into the opening, so that by the third time of raking the land is made clean and light. But if it should be found necessary to make the earth especially fine, a fourth man, with a still finer rake, is made to follow, so that in this way the land intended to be sown may be brought to any state of fineness by the use of rakes of different sizes. If, however, in the act of digging and raking, the land be found to adhere to the tools, this is an indication that it is still too moist for the operation, which should therefore be given up till the ground be found dry enough to permit of the rakes being used cleanly. While the weather continues good and favourable for the purpose, no time should be lost in having the seeds sown. In order to facilitate this, another batch of men should follow after those employed

in soil-preparation, so as at once to prepare the beds, sow the seeds, and cover them; for by such a simultaneous process no time is lost by bad weather intervening between the time of preparing the ground and having the seed sown. And the advantage in work of this kind is all the greater owing to the fact that the ground takes long to dry when wet weather comes on after the soil has been made so fine as described.

A part of the nursery may very conveniently be set apart for the preparation of light manure by collecting all weeds, &c., and piling them in heaps to rot; all leaves, turf, and other waste vegetable substances may be collected and brought there to rot and be mixed up with lime and new earth for being afterwards laid on the land as manure (see, however, the previous remarks on p. 103).

Land used as a nursery for the raising of young forest-trees must upon no account be kept up in a highly manured state, otherwise undue stimulation is given to the young plants; and when removed thence to a poorer soil, they wilt and droop, fail to establish themselves in the poorer land, and are often considerably impaired in ultimate value as timber crops. A new nursery may, however, perhaps require one dressing with farm-manure when the land is newly trenched, as in this state there seldom exists much humus or vegetable matter in the newly turned-up earth. But it is always safer to use good leaf-mould for the purpose; and later on it should be manured entirely with well-rotted weeds, leaves of trees or turf, and fresh soil carted from old fences or the boundaries of fields, with perhaps a slight admixture of lime to facilitate decomposition and humification. Attention should be paid to keeping a large store of good mould and decomposing vegetable substances in the manure compartment, and to seeing that, as the properly humified portions are laid on the seed-beds or nursery compartments, fresh quantities are collected for successive use.

A good method employed in Germany for stimulating the productivity of nursery-ground to a desirable, and not excessive, extent, is to sow a crop of lupine and then, instead of removing it for fodder when ripe, to dig it into the soil and allow it to humify. This plan is adopted with very satisfactory results on the poor sandy soil of the North German plain, where, even in producing Scots Pine chiefly, the nursery-ground soon requires stimulation. Like all other leguminous plants (vetches, lucerne, beans, &c.), lupine has the power of laying up stores of nitrogenous products in the root-nodules by the symbiotic aid of a bacillus; and, on humification, these and other food-supplies are returned to the soil in a form readily available for imbibition by the rootlets and suction-hairs.

Compartments Nos. 10, 10, together with the two borders 10, 10, extending in all to about 7 acres, on which the seedlings from the present year's sowing are to be planted next year, are not required

for any nursery crop till the following winter and spring; hence during the summer they may be sown with any grain crop that may be considered best for the district, as a remunerative return will thus be got from the ground while it necessarily lies unoccupied by any seedling crop. After the cereal crop is taken from this portion, it should be dug over in September or October, so as to rot the stubble, and improve the land before the seedlings are bedded out on it.

On the border No. 11, as indicated in the diagram, it is intended to raise Hollies and Hawthorns for hedges, as allowance was made for 2000 Hollies and 12,000 Thorns. In planting the Hollies, the work is performed in the same way as with regard to the other seedlings. They may be put in 4 in. apart in rows, at a distance of 10 to 12 in.; and the Thorns may be treated similarly. The Hollies should be well watered at the time of planting, as they are very apt to suffer from drought; indeed, so far as they are concerned, it is best to transplant them during wet weather.

Border No. 12 is devoted to plants requiring to be layered, such as the Lime-tree and English Elm, or engrafted like varieties of the Holly, Beech, Ash, Sycamore, and Elm. In the list on p. 107, 200 Lime-trees have been included for the purpose of layering on the border under notice; and if it should be wished to rear the English Elm also, an equal number of these may be bought for the purpose. For the mode of planting trees in the nursery-ground, and of propagating them by layering, see the details given in Vol. I. pp. 136, 137.

Any practical man who wishes to become a successful engrafter should attend a short course in a public nursery, where the art is necessarily carried to the highest perfection, and where there are men capable of giving more instruction in one day on the subject, simply by teaching the hand how to operate on the subjects, than could otherwise be conveyed at all. Besides the plants for hedging, and the plants for layering and engrafting, evergreens of different kinds may be planted on borders Nos. 11 and 12, as well as transplants of new sorts of coniferæ, and cuttings of various plants that may be wanted for ornamental purposes.

After these various works described have been all completed by about the end of May, it will of course be necessary to keep the seed-beds and nursery-lines free from weeds during the summer. Weeding is carried out with the hoe in dry weather before the weeds grow to any considerable size; for if the operation be left till the weeds are strong, the work becomes more costly, as well as more difficult to perform. The weeding of the seed-beds should be done in damp and cloudy weather, as then there is less likelihood of the soil coming away with their roots.

Towards the close of the second autumn, say in November, it will be necessary to ascertain the actual cost incurred in the formation and establishment of the nursery. In all probability it will stand as under:—

Sum outstanding on nursery at the end of the first year, and as particularised on p. 103				£736	9	0
To making, say 2000 yards of roads and walks at 1s. per yard				100	0	0
" 24,000 Privet plants for sides of walks, at 15s. per 1000				15	0	0
" cost of young trees bought in for the nursery, as per statement on p. 107				557	2	6
" cost of tree-seeds, as detailed on p. 107, say about				15	0	0
" planting 2,340,900 plants, as above, say at 1s. per 1000 over all				117	9	10
" expense of sowing tree-seeds, as above, say				10	0	0
" keeping clean nursery for one summer				85	0	0
" expense of collecting and preparing compost-heaps				10	0	0
" corn-seed for sowing 7 acres of compartments No. 10				8	0	0
" rent of 26 acres of nursery-ground for two years, say at 30s. per acre				78	0	0
" interest on rent for the first year, and which was not entered into the former account of expenses, at 5 per cent.				1	19	0
" Do. on sum outstanding at the end of the former year, at 5 per cent.				36	16	0
				£1770	16	4
Deduct from this value of grain crop on 7 acres of No. 10, say at £10 per acre	£70	0	0			
Do. value of 59,000 hardwoods, now supposed to be ready to plant out, at 30s. per 1000	88	10	0			
Deduct value of 780,000 2-year seedlings, one year transplanted Larch, now ready to go out, say at 20s. per 1000	780	0	0			
Do. value of 300,000 2-year seedling Pine, one year transplanted, at 10s. per 1000	150	0	0			
				1088	10	0
Sum outstanding at the end of the second year of the nursery, say at November 1893				£682	6	4

From the foregoing statement, which is based on practical experience in Britain, it will be seen that the entire sum outstanding on the establishment at the end of the second year is £682, 6s. 4d., after deducting the value of the crops ready to be removed from it, and leaving in the nursery all the other transplanted trees, as well as the seedlings grown on compartment No. 8. Were the whole stock of such an establishment to be sold, even at the end of the second year of its establishment, it would probably recoup the proprietor for the outlay. This point should be considered by all proprietors who intend planting largely on economic methods, for there are very decided sylvicultural as well as financial advantages in raising one's own stock of plants. Trees that are nursed and grown in any given district are always more likely to thrive well than when raised in a distant part of the country and brought in for planting to a tract where the climate may be of a totally different nature.

Annual Operations in the Nursery.—Similar operations of planting and sowing are continued annually as long as plants are wanted. Supposing, for example, that the broad-leaved species have been cleared during 1895 from compartment No. 3, Larch from 5, 5, 5, and Scots Pine from 7, and that all of these species have been planted out, then 7 acres 1 rood in the nursery-ground may be again put under green crop, in the spring or summer of 1895, preparatory to being planted again with the same sorts of trees during 1896; while the five compartments numbered 10 are to be planted in the spring of 1895 with the young seedlings that are now supposed to be raised in compartment No. 8, in every respect in the same way as has been already described; and the seeds for crop 1896 may be sown in any part of compartment No. 10 that may be considered convenient for the purpose. In planting and sowing, attention should always be given to a convenient subdivision of the compartments in order to prevent confusion.

Continental experience, on a far larger sylvicultural scale than is physically possible in Britain, has shown that the raising of green crops, in the manner above recommended by the author, is unnecessary. But the editor need not on this point reiterate his convictions already expressed on pp. 103 and 126.

Selection of Plants for Purchase.—Every proprietor who has occasion to plant must either have his own nursery or else supply himself from some nurseryman. In the latter case only healthy plants should be selected, and of such a nature as may be suitable for the situation on which they are intended to be planted out.

The proprietor should either himself visit, or cause his forester to visit, during the summer previous to the planting season, any nursery from which he intends to purchase his supply of young seedlings or transplants, in order to see that the stock of young plants is of a strong, robust character, in a clean, healthy state, and free from attacks of fungoid disease or noxious insects.

This may by many be considered unnecessary; but every experienced planter will be convinced of its necessity. Fungoid diseases are epidemic, and therefore diseased trees from a nursery may cause propagation of the same disease through several plantations in the neighbourhood. No respectable nurseryman would be guilty of intentionally sending diseased trees to any of his customers; but every planter or forester should, previous to making a purchase, go and visit the nursery-grounds, and judge for himself as to whether he shall buy or not. The proper time for such a visit is during the months of July or August, when the plants are in full leaf, and in their most vigorous growth.

During these months all the young plants should have the bark

of the stem and branches quite clean and free from any appearance of scale or lice; and when a little of the upper cuticle is removed with the finger-nail, the bark underneath should be of a pure, healthy, transparent green colour. The epidermis or upper cuticle of a young plant in perfect health should be easily removable from the inner bark.

It is also advisable to revisit the same grounds about the middle of October or early in November, in order to make the purchases required for the season; and it is absolutely necessary to bear in mind the nature of the soil and the situation to be planted. If the land be a thin soil upon a high situation, such plants should be chosen from the nursery as have stood rather wide in the rows, have had free air and room, and are rather of a low-set bushy character and a hardy appearance. For high situations the most suitable plants are one year's transplanted Pine, Larch, Spruce, and Fir, and broad-leaved species not exceeding 2 ft. in height. If tall slender plants, which have made long shoots of young wood during the previous summer, be chosen for such a situation, they will be sure to find difficulty in establishing themselves; and it is more than probable that many of them will die.

If the situation to be planted be low, sheltered, and with a good soil, somewhat tall well-grown plants may be chosen; for in such situations there is generally a tendency towards rank growth of grass, and unless the young plants be large they are apt to be choked by the herbage surrounding them. Above all, it is necessary that the young plants chosen should have a well-developed root-system with plenty of small fibrous rootlets and root-hairs, as these are the mouths by which the plant imbibes its food-supply of soluble salts from the soil. In rather a light and humose soil the roots of young plants are generally good; but if the soil be stiff and heavy, there is a risk of the roots being indifferently developed so as to have but few small fibres; and transplants with few fibrous roots, especially those of coniferous species of trees, do not establish themselves easily when planted out.

Lifting and Packing.—Careful lifting of the young plants from the seed-beds or nursery-lines is necessary in order duly to protect the roots. Pine seedlings or transplants in particular, if lifted out of the beds carelessly, are apt to lose a large portion of their roots; and consequently they have then greater difficulty in establishing themselves later on.

All plants that run to a strong tap-root, such as Pine, Larch, and Oak in particular, require careful treatment at the time of lifting and transplanting. In the case of Oaks that are to be used for coppice-woods, damage to the root system is not of so much consequence; but, for the formation of

young high-forest crops, it is essential to protect the root-system as well as possible. This is, of course, another argument, beside the purely financial point of view, for the use of small seedlings wherever the soil and situation will permit of it.

In purchasing the rarer sorts of coniferous trees from public nurseries, foresters should be very careful to see that they have not been tenderly reared in pits or frames; for if so, they will not have a fair chance of thriving, even if planted out on a moderately sheltered locality. All plants of this class should have stood at least two years in the open beds before being sent from the nursery.

When making purchases from nurseries, foresters should, if possible, have the plants lifted under their own superintendence, and removed before leaving the ground. Usually the nurserymen will be found willing to place workmen at their particular disposal for the time; and in this way all the young trees may be lifted and packed in the most careful and satisfactory manner.

In the pressing season of lifting orders in nurseries, the months of November and March, common untrained labourers have often to be employed in lifting plants that must be sent off by rail the same evening. In such cases these plants are often not sufficiently loosened by the men with the spades before those following pull them up from the earth; hence a large proportion of the fibres must get broken off. This of itself is objectionable; but when the plants have been tied up into bundles, their roots are sometimes allowed to lie exposed to the frosty air or the drying influence of the sun, thus exhausting the vitality of the plants, and rendering them more or less unfit for transplanting. But if personal attention be given by foresters to the lifting, packing, and transport of the planting material selected by them, then as a rule there is less probability of the plants wilting or drooping for a considerable period when they are put out on arrival at their destination.

At the time of packing for any lengthy transport it is advisable to mulch the roots of all naked seedlings in a loamy mixture, and to keep in the moisture by packing the roots in damp moss.

CHAPTER X.

THE TENDING OF TIMBER-CROPS.[1]

The Weeding of Plantations.—When any plantation has been formed, it is necessary to have the plants kept clear of all long grass or other weeds in order to preserve them in a healthy state and to prevent them from being injured by overtopping and overshadowing. Wherever the grass or natural herbage is likely to become so strong during the first summer after planting as to interfere with the normal development of the plants, weeding ought to take place by women and boys, who, with common shearing sickles, should be made to switch away all the grass, &c., from every young tree that may require to be cleared.

This work must be carefully supervised in order to see that it is properly carried out, as the boys employed are very apt to cut off the tops of many of the young trees if they are not strictly looked after. This operation ought to be performed twice during the summer season,—first between the middle and the end of June, and a second time in August; and where the trees stand among rank weeds, the process may perhaps require to be repeated for two or three years before the young trees have risen above the height attained by the herbage in the summer season.

Woody-fibrous weeds, like furze or whin and gorse or broom, often do more serious damage to young trees than grass and succulent weeds, that die down each autumn. If a crop of young trees be planted where furze and broom have been merely cut down without being grubbed out by the roots, the furze in particular is sure to throw out stronger and more vigorous shoots than ever during the following year. Wherever this may be the case, the forester must pay particular attention to see that these coppice-shoots of furze do not injure the young trees. For clearing away these shoots, a strong

[1] The attention of the student may here be called to the different treatment of this same subject in the editor's *Studies in Forestry*, 1894, chap. ix.

sickle will usually be found to answer the purpose quite well; and they ought to be shorn clean by the surface of the ground wherever they are found among the young trees, whether they may be injuring them in the meantime or not. Even though the furze may not interfere with the transplants in many parts of a young plantation during the first year of its growth, it may do so in the second year, when it will be much stronger and more difficult and expensive to cut out. It is therefore necessary to destroy such weeds during the first year of their growth; and besides this, if they are allowed to stand undisturbed upon the ground for a whole year, they give shelter to rabbits or hares, which are always inimical to the success of young plantations.

From a sylvicultural point of view **weeds** include all species of forest growth that may be growing out of place, or so as to interfere with the objects and intentions of the proprietor. Birch and Aspen thus frequently have to be operated against as weeds in well-managed woodlands. Both of these trees not only interfere with the normal development of conifers, but their foliage also acts as the host for the fungi *Melampsora tremulæ* and *M. Betulina*, whose teleuto-spores develop in the following spring into the Pine-shoot fungus *Cœoma pinitorquum* and the Larch blight *C. laricis*. See also the editor's translation of Kauschinger-Fürst's *Protection of Woodlands*, 1893, p. 63.

Even although furze may have been grubbed up, yet it is difficult to remove it so as to prevent any roots left in the ground sending up shoots of considerable strength during the following summer; hence young plantations where furze has previously existed require special attention. Large tracts of young plantations have often been ruined owing to their not having been cleared of weeds in due time; and in such cases replanting of the ground is often necessary, thereby entailing an outlay which might not have been necessary had due attention been paid to weeding operations.

The expense of operations carried out by a number of boys and girls under one man from the beginning of June to the end of August is usually about 16s. per acre for the first three years, where there is no furze; but where there is furze to contend with, the operation costs about 25s. per acre until the young trees rise above it.

The extent to which weeding operations are necessary in any plantation depends entirely upon the nature of the grass, herbage, &c., growing on the surface. It is quite possible that not even one-fourth of the extent of a plantation may require to have the young trees thus cleared; wherever they are likely to suffer from weeds, however, they need to be cleared, so as to obtain the requisite supplies of light and sunshine for their normal development. A good deal also depends on the size of the plants put out. When these are large, they require to be cleared only during the first year; and in this case an outlay of not more than 5s. per acre may be found sufficient.

Owing to the rapid cooling down of the temperature by radiation during clear nights in spring, the danger from late frosts is much greater in localities overrun by weeds than elsewhere; and this is an additional reason for the use of strong, stout transplants. On fresh or moist sandy or loamy soil, that will be almost certain to become quickly overgrown by a rank growth of foxglove, willow-herb, nightshade, balsam, ragwort, hawkweed, spurge, nettles, raspberry, bramble, and grasses of various kinds, the regeneration of existing mature woods should, as a rule, take place by means of natural reproduction under, and from seeds shed by, parent standard trees. On such classes of soil it is a comparatively easy and a highly satisfactory method of regeneration.

Cleaning and Thinning Operations.—Thinning is one of the most indispensable operations in Arboriculture; and a proper knowledge of the principles upon which thinning operations are based forms one of the most important branches in the education of the practical forester. Indeed, they rank next in importance to the fundamental principle underlying all economic Sylviculture, viz., that the productivity of the soil must be duly safeguarded against insolation and winds by a normal density of canopy in the crop (attained if necessary by underplanting).

In **Arboriculture** the object aimed at in thinning is the regulating of the trees in a plantation to such a distance one from another as is, from well-observed facts, known to be favourable to the health of each tree individually, as well as to the general welfare of the whole as a plantation. In order to grow any given plant to that size and full beauty of form and foliage which the species to which it belongs is known to attain under favourable circumstances, it is necessary that it have a sufficient growing-space for the spread of its roots and branches proportionate to its size at any given stage of its growth. Upon this the whole nature and intention of thinning ornamental plantations rests.

In **Sylviculture**, however, the leading aim is to produce the largest quantity of the most valuable timber capable of being produced by the soil; and this can be done only when the individual plants have just such measure of growing-space during their earlier stages of growth as will maintain them in healthy condition, but will prevent their extending laterally so long as they are still capable of growing vigorously in height. As has elsewhere been remarked on this point by the editor (*Studies in Forestry*, 1894, p. 185):—

"The object of thinning any crop is to stimulate and assist its development, so that the aim of the proprietor may be attained as completely and as soon as possible, without any such interruption of the canopy as may prejudice either the growth in height of the crop or the productive capacity of the soil. The crops which stand most in need of thinning, and of frequent repetition of the operation, are those in which the individuals are all of about the same age; as the natural struggle for individual existence is then more keen and prolonged than where some plants of advanced growth have from the very outset won an advantage. In the process of natural selection certain classes of stems become distinguishable—viz., (1) **predominating**,

(2) **dominant**, (3) **dominated**, and (4) **suppressed**. As, during the gradual process of death and decay which takes place when stems become suppressed, conditions obtain most favourable for the breeding of insect enemies and the propagation of fungoid diseases, this class should invariably be removed during thinning operations, whereby the freer circulation of air and the better utilisation of the food-supplies contained within the soil are also effected. To what extent a simultaneous removal of the dominated class should proceed, depends in each case on the concrete factors of soil, situation, species of tree, age of crop, mode of treatment, &c. If the struggle were left to nature unassisted, it would be carried out most rapidly on fertile soils, and would be so much prolonged in the case of shade-bearing species of trees on soils of merely average or inferior quality as to result in overcrowding of the crop throughout the pole-forest and young-tree forest stages of growth. From the sylvicultural point of view, the main objects of care are the timber-trees which it is desired to utilise on their attaining full financial maturity; and any measures that will tend to stimulate them to the speedy attainment of large, well-paid dimensions must deserve consideration. Year by year the number of individual stems from which it is possible that the future mature crop may be formed becomes diminished, and the removal and utilisation of all necessary stems is not only a means of improving the growth of the predominating and dominant portions of the crop, but is a source of revenue, which should be realised as soon as available in order to reduce the capital cost of the crop henceforth till its final clearance."

There is a decided loss of timber, as well as of shelter, whenever plantations are made too thin; but there is also a loss where they are not sufficiently thinned. Wherever plantations have remained long in a close state, and are thinned suddenly and heavily, the operation is injurious to their development; for foliage growing in shade is not always able to adapt itself at once to the changed conditions implied by considerably larger supplies of sunlight and warmth. If the situation be sheltered and the soil dry, however, the recovery of an overthinned plantation generally commences with the next year's flush of new foliage; although the trees, after once being permitted to extend laterally, will never attain that length of bole which otherwise they would have reached in their individual struggle for light and air.

On cold exposed situations, where, under any circumstances, the vital energy is less vigorous, the prejudicial effects of injudicious thinning are of course more lasting. But on the other hand, when plantations are not sufficiently thinned, the trees become drawn up and weakly, and their natural energy of growth becomes dissipated (1) in the struggle for supremacy in the case of the more vigorous individuals, and (2) for life itself in the case of the dominated individuals. Where crowded coniferous plantations stand long without being thinned, thinning operations require to be performed very carefully; otherwise, if blanks be formed here and there, the wind may cause great havoc during storms, especially in the case of shallow-rooting species of trees, like Spruces.

In addition to danger from windfall, crowded coniferous crops are much more exposed to injury from snow and ice, fungoid diseases, and insect attacks, than woods of **normal density** merely. But normal density is a term that varies with regard to each species of tree in direct proportion to its **demands for light**, and in the inverse ratio of its **capacity for bearing shade**. Thus a crop of Beech, Maple, Sycamore, or Elm will, each in their own degree, remain in healthy vigorous growth with a greater density of canopy than Oak or Ash; whilst Spruce, Silver Fir, and Black Pines will naturally thrive best as woodland crops with a larger number of stems per acre than Scots Pine or Larch woods can show. The **normal density of canopy** in well-managed woods is therefore only a relative term, dependent on the species of tree forming the wood. And it also varies according to soil and situation; for the poorer the soil, and the less favourable the situation, the larger will be the number of stems per acre, but the smaller the quantity of timber produced.

Sometimes mixed plantations of considerable age and extent may be seen, in which conifers overtop and keep back the broad-leaved trees, and where it is evident that thinning operations have never been properly conducted. The broad-leaved trees may still only be striving for existence; whilst the Firs and Pines, which, of course, grow more rapidly, are of too spreading a habit, from having been widely planted among the hardwoods. Such land may be well adapted to the growth of broad-leaved trees; yet, if the plantations be permitted to grow so as to allow the conifers first to catch up and then outgrow and crush the former, the management is not economical. But if the conifers be thinned out gradually and used for estate purposes, they will prove of value to the proprietor, and at the same time leave a more valuable crop of hardwoods on the ground. If thinning operations be neglected, however, then, instead of a valuable crop of broad-leaved species, there may only be a patchy crop of conifers of much less permanent or ultimate value.

The density of plantations must, at all stages of their development, depend on the nature of the soil and situation upon which the trees grow, the condition of the crop, and the ultimate object the proprietor may have in view as regards any particular plantation.

For all thinning operations, no matter whether carried out arboriculturally or sylviculturally, the golden rule is to **begin early, thin moderately, and repeat frequently.**

But if the thinning is to be done **arboriculturally**, *i.e.*, if in any ornamental plantation it should be intended to rear up trees for park or lawn scenery, then, in such a case, the distance between each individual tree may be about equal to the height of the same. And this comparative freedom should be maintained at all stages of growth after the first thinning has taken place, in order that the individual stems may have sufficient growing-space to form spreading tops as

well as massive trunks. This is the true and natural form of every tree, which constitutes the great beauty of lawn-trees.

If, however, it be intended to grow woods principally for the sake of valuable timber, then, so long as the trees are capable of being stimulated or continued in energetic growth in height, their individual growing-space should be limited to the actual coronal requirements of the given species, under the given circumstances as to soil and situation, in order to maintain the crop in a normal and healthy condition.

In previous editions of this work it was stated that:—

"If it is intended to rear up a plantation of Firs or Pines for the sake of shelter and timber, the distance between each tree may be about the third of the height, which is the distance found most favourable to the useful development of the Fir and Pine tribes as timber trees."

As Ramann points out,[1] the struggle that goes on between the individual plants forming the crops on crowded areas extends to the following matters:—

1. Absorption of the soluble nutrient salts in the soil.
2. Imbibition of the soil-moisture.
3. The crowns interfere with each other in the struggle for light and air, whilst the root-systems become abnormally developed in their endeavour to obtain sufficient supplies of food and moisture.
4. The physical condition and properties of the soil become prejudicially affected.
5. The normal process of humification of the dead foliage and twigs that fall to the ground, is interfered with.

These factors in the struggle are always more or less concurrent in crowded woods. Hence it is often difficult to tell, in any given case, which is the main cause most active in interfering with the normal development of the crop.

Thinnings should be carried out, not with a view solely to the realisation of revenue, but primarily in order to improve the marketable quality and value of the crop on the ground. So far as this primary object is concerned, these cultural operations are similar in nature to the **weedings and cleanings** of the young crops during earlier stages of development. But the term **thinning** is properly applied to the operation only when the value of the poles cut out repays, or more than repays, the cost of cutting them out.

The author's has been the general opinion in Britain; but it is entirely erroneous. It is based on a total misconception of the nature of tree-growth and of the actual statistical facts connected with woodland crops (see editor's *British Forest Trees*, 1893, pp. 22 to 54). Thus Spruce and Silver Fir attain greater heights than Scots Pine; therefore, according to the above rule, they should apparently be thinned to a greater extent. But as they are **shade-bearing** species, whilst the latter is **light-demanding**, they really do not require to be thinned to the same extent. The same reasoning may also be applied to Beech as compared with Oak and Ash on soils where the Beech attains a greater height than the latter genera. The necessity for thinning, the frequency of the operation, and the extent to which it should be performed, depend, *cæteris paribus*, on the extent to which any given species of tree can bear shade.

[1] *Forstliche Bodenkunde und Standortslehre*, 1893, p. 459.

The Conduct of Thinning Operations.—After proper soil-preparation, good planting, and adequate density of crop, **systematic thinning** is of the greatest influence in bringing sylvicultural crops to their highest technical utility and monetary value. And although the principles of thinning are neither so well understood nor the practice so regularly adopted in Britain as on the Continent, yet a considerable advance has been made in this respect during the last ten or twelve years.

Although many foresters understand and apply systematic thinning to the woods and plantations they have the management of, still there are as many who are not possessed of this knowledge, or at least do not act upon it; and to this is to be attributed the great extent of inferior crops found in many parts of the country, upon all descriptions of land, and on large and small properties alike.

The opinion of Continental sylviculturists as to the essential importance of thinning operations with regard to the ultimate marketable value of woodland crops and the utility of the timber produced has already been practically stated in the quotation previously given from Gayer's *Waldbau* (see Chapter on *Planting*).

In explaining the **theory and practice of thinning**, the same authority (*op. cit.*, pp. 550–558) points out that the necessity for thinning depends on the following factors:—

1. **The Age of the Crop.**—During the first third of its life-period, the natural process of elimination of crowded-out individuals is relatively much greater than during the later stages of growth.
2. **The Species of Tree.**—In comparison with the **light-demanding** species, Scots Pine, Larch, Oak, Birch, &c., the **shade-bearing** species of trees only require, on the average, from 50 to 75 per cent. of the individual growing-space requisite for the healthy and normal development of the former.
3. **The Soil.**—Until the 60th to 80th year of age, the individual growing-space on poor soil is often considerably less than on land of a better class. But the difference in number in this respect becomes all the more marked, the less light-demanding the species concerned may be.
4. **The Elevation above Sea-level.**—The higher the locality, the greater the number of stems per acre, although the individual trees diminish in height, girth, and cubic contents.
5. **The Aspect.**—As regards Beech, for example, southern and western exposures have about 5 per cent. more stems, on the average, than northern or eastern slopes.
6. **The Slope or Gradient.**—Hill-sides accommodate more stems than level land, owing to the greater amount of light available for the individual trees. But this is practically balanced by the fact that land on the plain is generally deeper and more productive than that on hill-sides.

The practical conclusion from all the above considerations is, that the average growing-space per individual stem is greater, (1) the older the crop, (2) the more light-demanding the species of tree, (3) the better the soil, and (4) the lower the elevation of the land above sea-level; and *vice versâ*.

Whenever the **necessity for thinning** is considered in any given case, all these factors must be noted in their concrete forms. First of all the **density of the crop** must be considered, as woods raised by natural regeneration or by sowing will, throughout all the earlier stages of their development, be much denser than plantations usually are. The second consideration is given to the **age of the crop**; for the need of thinning will of course be greatest during the pole-forest stage of development, when the assistance given to nature in the struggle for supremacy on the one hand and existence on the other, and in the premature elimination of those individuals that would in due course of time be killed off, tends to conserve the energy of growth of the larger individuals, and to enhance their capacity for producing timber. The third point for consideration is the **species of tree**, as light-demanding kinds naturally require more individual growing-space than those whose internal and lower foliage can carry on the work of assimilation with less of direct light and sunshine. And finally comes consideration of the **soil and situation**; for wherever, owing to inferiority of the soil, or to elevation above the sea-level, the struggle between the individuals for supremacy or existence is of long continuance, this logically points to a greater necessity for assisting nature than on more fertile soils or more favourable situations, where the elimination of the less vigorous poles or trees proceeds more rapidly when left entirely to nature. But, in addition to these ruling considerations, account must also be taken of the local dangers from ice, snow, and storms, which threaten specific crops to a different extent, and which, even for one and the same species of trees, are mainly dependent on elevation, exposure, and gradient.

To delay thinning operations (or more correctly, to neglect **weeding and cleaning** in thickets, in order to await the time when **thinning** can be performed without any monetary outlay for those operations of tending) until the poles cut out may find a more favourable market is not true economy. As Gayer very well remarks:—"The saving thus effected is only deceptive; because it is exceeded by the loss of increment on the standing ultimate crop, in all cases in which the price of timber has not sunk to its absolutely lowest level. By beginning thinning operations early, and continuing them energetically, the enhancement of increment in the growing crop can be stimulated to such an extent on a good soil, that the same production of timber may be anticipated at from ten to twenty years earlier than it would otherwise be obtainable."

Thinning operations should be repeated at regular intervals of a few **years**; but the actual number of years depends mainly on the age and the energy of growth of the crop, and on the species of tree. In pole-forests of light-demanding species, thinning will have to be repeated most frequently; in tree-forests of shade-bearing species, the need for thinning will be least. In the former class of young woods (Oak, Ash, Larch, Scots Pine) thinnings should, if possible, be repeated **every five years**; whilst in pole-forests of shade-bearing species (Spruce, Silver Fir, Beech, and sometimes Maple and Sycamore), it will usually be sufficient to thin once every eight or ten years during the pole-forest stage of development.

Considerations regarding the conservation of the productivity of the soil of course demand that on inferior qualities of land the thinnings should be slighter, but more frequently repeated, than on good soil. Although on the former class nature requires more assistance in the elimination of the weaklings, yet the productive capacity of the soil is more apt to be injuriously affected even by the temporary and slight interruption in the leafy canopy, and the consequent partial exposure of the soil to insolation.

As long as thinnings are not carried so far as to interfere with

increment in height and with the formation of a long, clean bole, free from branch-knots, and having a good form-factor, *i.e.*, a high relative proportion between the top-diameter and the base of the bole, their influence is beneficial. But wherever they tend to prejudice, as is so often the case in Britain, the finest development of the stem for technical purposes, they must, of course, affect the financial value of the woods, even when they do not go so far as to endanger the productivity of the soil, in violation of the first fundamental principle of Sylviculture.

On all large woodland estates the crops should be classified in as nearly equal portions as may be convenient; and each of these portions should be periodically and systematically thinned once in 5 to 10 or 15 years, according to the nature and the ages of the respective crops. Wherever this system is put into operation, it must not only be attended with great advantage to the crops, but will also lessen the expense of labour, as well as bring in a regular, and usually a larger, revenue than would otherwise be obtainable.

Such a **Plan of Thinning Operations** may be in the following form, or in any other that seems to be most convenient for the given local circumstances:—

Name of woods.	Description of crops.	Age in years.	1 Acreage from 0 to 15 years.	2 Acreage from 15 to 25 years.	3 Acreage from 25 to 35 years.	4 Acreage from 35 to 45 years.	5 Acreage from 45 to 60 years.
			A. R. P.	A. R. P.	A. R. P.	A. R. P.	A. R. P.
Redbraes . .	Oak with Larch as nurses .	10 & 16'	200 0 0	104 2 0	...	...	...
Greenhills . .	Larch and Pine	32	...	...	236 1 20	...	...
Stanford . .	Oak	50	...	...	...	...	480 0 0
Raeburn . .	Larch and Pine	43	...	...	...	208 2 20	...
John's Wood .	Ash	...	...	...	36 3 0	...	...
Lead Hills . .	Larch and Pine	7 & 20	105 0 0	204 3 0	...	...	...
The Grove . .	Oak, Sycamore, and Elm . .	58	...	...	...	...	79 1 0
Tom's Meadow	Oak	40	...	...	...	90 0 0	...
Wallsend . .	Oak, Ash, Elm, and Larch .	40	...	...	...	206 3 0	...
Nord Hill . .	Oak with Larch	8 & 17	105 3 0	200 0 0	...	...	...
Ann's Brae. .	Larch and Pine	30	...	...	97 1 0	...	...
Thuylaw . .	Oak	2 & 40	100 0 0	...	...	125 0 0	...
Bar Muir . .	Larch . . .	15	...	90 0 0	...	...	...
Revach . . .	Pine	50	...	...	...	...	80 0 0
Castle Hill. .	Larch . . .	20	...	35 0 0	...	...	...
Stainton . .	Oak	32	...	...	40 0 0	...	...
Yarrow More .	Oak	28	...	...	60 0 0	...	...
Eildon More .	Larch	25	...	...	104 0 0	...	...
James Wood .	Pine	30	...	...	36 0 0	...	...
Dunedin . .	Oak and Larch	5	100 0 0	5 0 0	...	...	...
			610 3 0	639 1 0	610 1 20	630 1 20	639 1 0

The **weeding and cleaning** operations under column 1 will of course be cultural operations of a nature not immediately productive. The **thinning** operations under columns 2 and 3 may, according to the concrete conditions of crop and soil, be arranged to be repeated every 4, 5, or 6 years, as considered necessary; those under column 4 will probably not be required more than once every 5 to 8 years; whilst those in column 5 may only need to be repeated once every 8 or 10 to 15 years. It would be mis-

leading to attempt to say more for practical guidance in thinning operations than has above been stated. No hard and fast rules can be laid down. The only safe guide is the rule previously given: **Begin thinning early; conduct the operation moderately; repeat it frequently.** But in this aphorism the words **early, moderately,** and **frequently** have a signification which, in the case of each individual crop that may be under consideration, depends entirely on the concrete factors that have previously been named and discussed.

In the treatment of mixed woods the thinning operations must be conducted in a somewhat different manner, or on what might even be called a different principle. Thus, in order to protect an ultimately more valuable **species** of tree, it is frequently necessary to remove a finer **individual** tree of a less remunerative species wherever the latter threatens the existence, or even to prejudice the development, of the former.

Average Returns in Material Yielded by Thinnings have not yet been collected and tabulated for Scotland and England. Hence we must, in the meantime, look to the Continent in order to see to what general extent thinnings may be expected from sylvicultural crops of normal density for the given species of tree. So far as Britain is concerned, the data must be considered approximate only. Some allowance must of course be made for climate; and in this respect the following figures would, under equally good management on the part of the forester, probably prove below the results obtainable in Southern England, and above those obtainable in Scotland. The following data are taken from Burckhardt's *Hülfstafeln für Forsttaxatoren*, 1861. They refer to the sylvicultural circumstances of Hanover, where forestry has long been practised in a very high-class manner.[1]

I. Thinnings from Beech Woods (including small branches), in cubic feet per acre and per decade.

Age of Crop—Years.	Quality of soil and situation.			
	Very good; crop very dense.	Good.	Average.	Inferior.
Up to 30	180	135	90	60
30–40	375	270	180	90
40–50	420	315	210	105
50–60	420	300	180	90
60–70	390	270	165	90
70–80	360	255	150	75
80–90	345	240	150	75
90–100	330	240	150	75
100–110	330	240	150	75
Total	3,150	2,265	1,425	735
Average annual yield	28½	21	13½	6

II. Thinnings from Oak Woods.

When full crops are raised from seed on land of the better class, considerable returns may be obtained in the way of clearings before the 20th year. From then onwards the conduct of thinning operations in the steady

[1] Grebe's generalisations for the Saxe-Weimar forests of Thuringia may be found, for comparison by the student, in *British Forest Trees*, p. 24.

heavy manner most beneficial to the Oak removes about 300 to 450 cubic feet per acre during each decade. The following average yield may be reckoned :—

Under favourable circumstances,	375 to 450 cubic			acre and per decade.	
" average "	300 " 375	"	"	"	"
" unfavourable "	225 " 300	"	"	"	"

These higher calculations have more especial reference to the tree-forest stage of development.

When a *partial clearance* (*with under-planting*) is conducted about the 80th or 100th year, then further intermediate returns from the main crop are dispensed with or discounted; but the partial clearance itself utilises a large proportion of the crop, and accelerates the maturity of the remaining portion.

III. Thinnings from Pure Spruce Woods, in cubic feet per acre and per decade.

Age of Crop—Years.	Quality of soil and situation.		
	Good.	Average.	Inferior.
Up to 30 . . .	225	150	75
30–40 . . .	405	330	240
40–50 . . .	480	390	300
50–60 . . .	450	360	270
60–70 . . .	420	330	225
70–80 . . .	390	300	210
80–90 . . .	360	255	180
90–100 . . .	330	195	...
Total . .	3,060	2,315	1,500
Average annual yield .	30	22½	16½

From the 30th to the 80th year, thinnings of 330 to 400 cubic feet per acre and per decade are usual in crops of the average and better classes. Where there is danger from snow or ice, the thinnings should be reduced in quantity.

IV. Thinnings from Pure Scots Pine Woods, in cubic feet per acre and per decade.

Age of Crop—Years.	Quality of soil and situation.		
	Good.	Average.	Inferior.
20–30 . . .	405	360	270
30–40 . . .	375	330	240
40–50 . . .	330	285	210
50–60 . . .	300	240	150
60–70 . . .	270	195	105
70–80 . . .	240	150	...
80–90 . . .	225	...	..
Total . .	2,145	1,560	975
Average annual yield .	24	19½	13½

In very full or dense crops, on soil that is not too poor in quality, from 450 to 600 cubic ft. of brushwood and small material may be removed per acre before the 20th year. When thinning only commences about the 25th to 30th year, then the quantity of material removed is, on average and good lands, usually as follows:—

In full or dense crops, . .	315 to 360	cubic ft. per acre and per decade.
In crops of average density, .	240 „ 300	„ „ „ „
In dense crops on inferior land,	135 „ 180	„ „ „ „

By delaying thinning operations in Scots Pine crops a loss of utilisable material is incurred, especially in young woods.

Formation and Tending of Oak Woods.[1]—More care and attention is perhaps given to the cultivation of the Oak in Great Britain than to any other of our forest-tress; for it is of value not only on account of its timber in high-forest, but also of its bark in coppice-woods.

Three different systems of raising young Oaks are practised in Britain, viz.:—

1. Sowing or dibbling of acorns into the soil wherever it is intended to form the crop.
2. Transplanting seedlings from the nurseries in the usual way, and then, when their roots are once firmly established, cutting back each stem close to the ground, and allowing the stock to throw up a number of young shoots. From among these a choice is made of one to remain, whilst all the others are destroyed.
3. The system of putting out schooled transplants in pits, as is usually done, and allowing them to develop naturally.

This entirely overlooks the most natural method of regeneration of Oak-woods, by reproduction from seed shed by parent standards—a method very extensively carried out on the Continent, and with excellent results. That this was also, during the sixteenth century, employed in Britain is evident from the following extract from Lascelles' pamphlet on *Arboriculture of the New Forest*, 1893, pp. 3 and 4:—

"As has been stated before, the forest laws did something for the preservation of the crop of timber actually on the ground, but did nothing towards reproducing it when by natural decay it perished. That encoppicements, and even plantations, were made, seems probable, because the preamble to the first statute passed upon the subject—that of 22 Edward IV., in A.D. 1483—refers to the restrictions placed upon planting by the forest laws, which regarded the preservation of game as the foremost consideration. But by subsequent statutes—those of the 35 Henry VIII. and 13 Elizabeth—the practices of encoppicement were made imperative in the royal forests, and many orders and proclamations were made in accordance with them.

"The records of the Court of Exchequer abound with memoranda of

[1] See the remarks previously made on pp. 95–97 of Vol. I. (Chap. II.); also *British Forest Trees*, 1893, pp. 193 *et seq.*

the cost of erecting fences for the exclusion of the cattle and deer from the various copses or woods in different parts of the forest, commencing with the reign of Henry VIII. In the seventh year of Elizabeth we have a return of 'all Her Majesty's woods in parks, forests, and chases,' in which is given a most complete list of the ancient woods of the New Forest, some of which can be traced at the present day, though in most cases the sites, being land well suited to the growth of timber, have been replanted with younger wood at some intermediate period. But there is hardly an acre of land which would grow timber naturally that is not referred to in this return.

"The practice of cultivation seems to have been that of 'natural regeneration,' such as is advocated by the most distinguished foresters of the modern school. In old days it went by the name of encoppicing, and the process seems to have been simply to enclose the area by a fence against cattle and deer, and to rely on the natural reproduction of the seed from the existing crop of trees to replenish the wood. After the coppice was fairly established, it seems to have been the practice to farm it out on lease for a term of years, but under certain restrictions as to the preservation of timber. Thus in A.D. 1571 we find a presentment of the regarders of the forest to the effect that 'a coppice called Ridley Coppice hath been spoiled by cattle by one John Marlowe.' To this careful attention, it may be, we owe it that we are now able to enjoy the beauties of Ridley Wood—without exception the most beautiful of all the woods of the New Forest as it now exists. Such presentments, however, abound in the records of this reign, and it is clear that great pains were taken to keep the numerous young coppices free from all manner of cattle. These coppices are the old woods which are the glory of the Forest at the present day."

As the system of sowing or dibbling in the acorns has already been considered in Chapter IX. (p. 122), no further reference need here be made to it.

Although the second system,—that of transplanting the young trees from the nursery into the open, and then, when their roots are fairly established, cutting them back, and finally choosing the strongest and healthiest shoots for permanent development,—is much practised in high-lying districts, where young hardwoods are apt to suffer when newly-lifted from a sheltered nursery, yet it can certainly not be recommended for the formation of high-forest crops. Both from the physiological and the practical points of view, it would be infinitely preferable to raise the plants in the vicinity of the land to be planted up, so as to have them acclimatised naturally. Where, however, hardy plants are not obtainable, then circumstances must be submitted to, and this system of cutting over is only assisting nature; for as soon as the plants are cut over, they each send up from three to six vigorous young shoots, which can be removed, with the exception of that left to form the permanent stem. By adopting this method strong vigorous young shoots of 2 ft. high may sometimes be obtained during the second year after planting; whereas, if the plants be not cut back, three or four years may elapse before shoots are formed of the same strength.

But any such deliberate crippling of plants, except for purposes of coppice-formation, is a direct interference with the vitality of the tree, which may exhibit its influence in the later stages of development. Sylvicultural experience in Germany has distinctly shown that high-forest crops raised from stool-shoots cannot attain the same longevity as crops raised directly from seed; the former begin to flag earlier in annual increment.

Some foresters even cut down the plants, immediately on receiving them, to within 3 in. of the roots, and plant them in this state in the pits which have been prepared for them in the open; and they assert that they thus gain young shoots a year sooner than if they had allowed the plants to remain for one year in the ground previous to being cut over in the usual way. But, upon examining the state of the young plants which are thus cut back previous to planting, the shoots produced will be found to be weak during the first season; as a matter of fact, no vigorous growth is made till the second year. Hence something is lost instead of gained; for, until the roots of the young plants are fairly established, very little young wood can be produced. The plants require a full year in order to establish their roots; if they are forced to make wood during that year, the wood seldom ripens well, but is weak and apt to be nipped by the first frost of winter. But when the young plants are permitted to establish themselves during the year after being planted, and are only then cut back, they always make more vigorous and stronger shoots in that one season than plants of the same class cut at the time of planting and having two years' growth of shoots.

Both modifications of the system are, however, objectionable. They can only be justified, so far as concerns the raising of high-forest, when acclimatised plants can absolutely not be obtained. And even then the use of sturdy, well-developed small transplants would, in the long-run, be preferable to this wanton mutilation of the seedling Oaks.

The third system, that of planting the young trees in pits, and allowing them to develop naturally, is the usual method practised in all moderately sheltered districts for Oaks, and for all other sorts of young trees not above 4 ft. high, which have been twice transplanted in the nursery, so as to give them well-fibred roots. Sometimes on soil not of first-rate quality, and in exposed situations, the plants may find great difficulty in establishing themselves, in which case the normal balance between imbibition and transpiration is so much disturbed that the stem may die off; but if the soil be good and the root-system remain active, then young shoots may be sent up to supply the place of the dead stems, and as these grow up they become acclimatised, and continue to develop healthily.

As has previously been stated (see Vol. I. p. 467), the younger the seedlings or transplants are, the less is the disturbance caused. Hence, unless special dangers exist from weeds, &c., the use of young plants is preferable, not only for economical reasons, but also with a view to the most successful establishment of the young crop.

Different opinions prevail in Britain as to the distance at which young Oaks should be planted when it is intended to raise up an Oak wood, and not merely an ornamental plantation. The broad general question—*At what distance ought Oak to be planted with the view of realising the greatest possible profit from the land in the shortest possible time after planting?* cannot be answered in any definite manner. For in one neighbourhood young Oak poles may be of considerable value, whilst in another they may be comparatively worthless; and in any given locality young Larch thinnings may be in demand, while Oak may fail to find a ready or remunerative market.

From the purely financial and sylvicultural points of view, it may be generally stated (Nisbet, *op. cit.*, p. 210) that—

"Very good results can frequently be obtained by the use of two to three year-old transplants in rows of 4 to 5 ft. by 3 ft. When older transplants are desirable, the distances at which they are put out vary from about 4 ft. by 4 ft. to 10 ft. by 10 ft., or the equivalent growing-spaces if in rows, as the initial cost rapidly increases with the size of the transplants."

Wherever Oak plantations are raised in any exposed parts of the country where this species does not grow rapidly, it is necessary to scatter Larch or Pine among the Oaks as nurses.

In such cases it should always be borne in mind that the main crop is Oak; hence, whenever the time comes for the nurses to be removed, they should be cut out immediately. To let the Larch or Pine stand for two or three years after they are no longer required, in the hope of getting better returns from the thinnings, is to deliberately prejudice the ultimate development and value of the main crop of Oak.

In the above the Pine is spoken of as a nurse; but it must only be regarded as a nurse, and not as a timber-tree,—for soils that are good enough to plant with a crop of Oak are usually much too rich for the production of sound resinous durable Pine. When the soil is too rich, the wood of the Pine is apt to be spongy and not well able to resist either fungoid infection or the attacks of insects.

But in more sheltered districts, where there is little doubt of the Oaks thriving, an admixture of Beech is preferable in order to improve the soil.

This matter, however, branches off to the advantages to be derived from mixed woods over pure crops,—a subject that has already received attention elsewhere (see Vol. I. p. 518; also the editor's *British Forest Trees*, 1893, pp. 170 and 201; and *Studies in Forestry*, 1894, chapter vi.).

When a proprietor meditates forming a pure Oak forest, without admixture of any other species of tree, he should first consider whether young Oaks, cut down in the process of thinning, will sell to advantage in his neighbourhood, and if they will pay him better than any other sort of wood of the same age. Suppose, for example, that young Oaks for spokewood sell well, *i.e.*, about 5 to 8 in. in diameter, and suitable for making the spokes of wheels, then it might be advisable for him to plant the young Oaks at 8 ft. apart, and to fill up the land with Larch and Beech to about 4 ft. by 4 ft. over all. By the time the Larch are gradually cleared out, the Oak and Beech will form good canopy, and the crop can then be tended with due regard to the finest development of the former.

Wherever the circumstances of the soil and situation or the demands of the local market point to a preference of other crops than Oak, then it is much more economical and advantageous to form mixed woods in such manner as best to meet the market requirements, while at the same time taking due measures for the safeguarding of the productivity of the soil, either by the admixture of shade-bearing species, or, if necessary, by under-planting when the crop becomes naturally too thin in canopy to protect the soil against the deteriorating effects of sun and of currents of air. To attempt to introduce a rapidly developing species like Larch—for any other purpose than a **temporary nurse**—into crops of a light-demanding species like Oak, must argue want of knowledge of the normal demands of the different species of trees for light, and of their different capacities for bearing shade.

When an Oak plantation has attained the age of 8 or 10 years, the nurses should be cleared out wherever they seem to interfere with the Oak. This operation must at all times be more severe than when clearing away nurses from among the common kinds of hardwood. And, indeed, this forms the only difference worth mentioning between the cultivation of the Oak and the cultivation of hardwoods in general—that after they are once properly established in the ground, the Oaks **must**, throughout the whole course of their later development, have more room and air than any other species of hardwood-trees.

In other words, the Oak is a **light-demanding** species of tree. The author's **arboricultural** explanation of the above fact was as follows:—

"The reason of this difference as regards the cultivation of the Oak is this: The Oak is a valuable tree, both on account of its wood and bark: the wood is more valuable when grown of proportionable diameter than when of great length, and it is also of more durable quality when freely exposed to the air than when drawn up weakly and to a great height; thence arises the necessity of giving the trees free circulation of air in order to have valuable wood. The Oak is also valuable on account of its bark, as we have already mentioned. Now, in order to produce bark, a tree must have extent of wood, whether that be in the

form of trunk or branches. When Oak-trees have free room for expanding themselves, the lower branches form into bends for shipbuilding, which is a valuable object. The trees also, being more branchy in themselves, possess a greater surface for the production of bark; and the bark itself, having free air, becomes thick and heavy upon the tree. It is perhaps not generally known that Oak-bark produced upon trees having free air about them weighs almost double that of an equal surface taken from a tree confined and not having air; and, at the same time, bark of such weight is always more valuable, because containing a greater proportion of tanning matter."

The editor's **sylvicultural** statement of the case, however, is that the object of growing Oak-woods is to obtain the largest monetary returns without endangering the productive capacity of the soil. Crooks for shipbuilding are no longer so remunerative as fine stems. Hence timber having a long straight bole, free from branches or knots, and with a relatively large top-diameter in comparison with the butt-end, will serve higher technical purposes, and will consequently command a higher value, than timber of the class described by the author. But timber of that fine, straight, clean description can only be produced by maintaining the crops in good canopy till their growth in height has culminated, and by then thinning them well and under-planting the standard trees (see *Studies in Forestry*, chaps. ix., x., and xi.).

Sylvicultural experience on the Continent has shown that the most advantageous manner of producing Oak-timber in high-forest is gradually to thin out pure crops when they culminate in rate of growth in height about the end of the pole-forest stage of development during the first third of their life-period as sylvicultural crops, *i.e.*, about the fortieth to sixtieth year of age, according to the nature of the soil and situation. If under-planting has been neglected by the time the soil begins to become overrun with grass and weeds, then this is a sign that the work should be no longer delayed in the interests both of the soil and the growing crop.

Here is what one of the greatest and best sylviculturists of the century, Burckhardt, says with respect to the tending of Oak-woods (*Säen und Pflanzen*, 1893, p. 9):—

"The best method of tending woods lies in THINNING. No species of tree requires such *strong* thinning as the Oak [and the Larch]. Where thinning is neglected, or performed too late, or carried out to an insufficient extent, unsatisfactory development of the Oak is the necessary consequence. Poor crowns, conical form of bole, and even the frequent formation of stem-shoots, &c., are ominous signs. Fulness of bole and a well-developed crown are the favourable signs that give promise of a good future for the Oak.

"One may hold only to *moderate* thinning in general; but so far as the Oak is concerned, something more than that must be done. Without interrupting the leaf-canopy to any injurious extent, the thinning of crops or patches of Oak must be begun *early* and be repeated frequently till the age of tree-forest, unless the second portion of the life-period is to be passed with underwood formed after a partial clearance extending beyond the limits of a mere thinning.[1] Crowding of the individual trees, indefiniteness with regard to the predominating class of stems, and a long struggle for supremacy, are even less desirable in Oak-woods than in other crops; hence the thinning must be of a *somewhat anticipatory nature*, and must include all stems that are not necessary for the maintenance of the leaf-canopy. In the older woods, even the formation of small blanks, caused here and there

[1] This method of stimulating the increment in tree-crops approaching maturity, is fully described in the editor's *Studies in Forestry*, 1894, chap. x.

by the removal of trees, need not be avoided; for they soon close up again. In *early and oft-repeated thinning* lies the best tending of the Oak; and for the maintenance of a good leaf-canopy, the *frequent* removal of individual trees of backward growth is often the most prudent measure. When the axe has been early and continuously made use of in Oak-woods, considerable minor returns are not only harvested from the timber and the bark, but at the same time the most favourable conditions are secured for the growth of the trees forming the main crop, whilst the most advantageous development in the stem and the crown of foliage is likewise attained."

When crooks were in good demand, the raising of Oak standards in copse was about the best way of cultivating this species. But the market has now changed; and landowners must just study the conditions of the latter. In the above, and in the special references made, the editor has endeavoured to make clear the best methods of attaining such an object, so far as explicitness can be attained without teaching in the woods themselves.

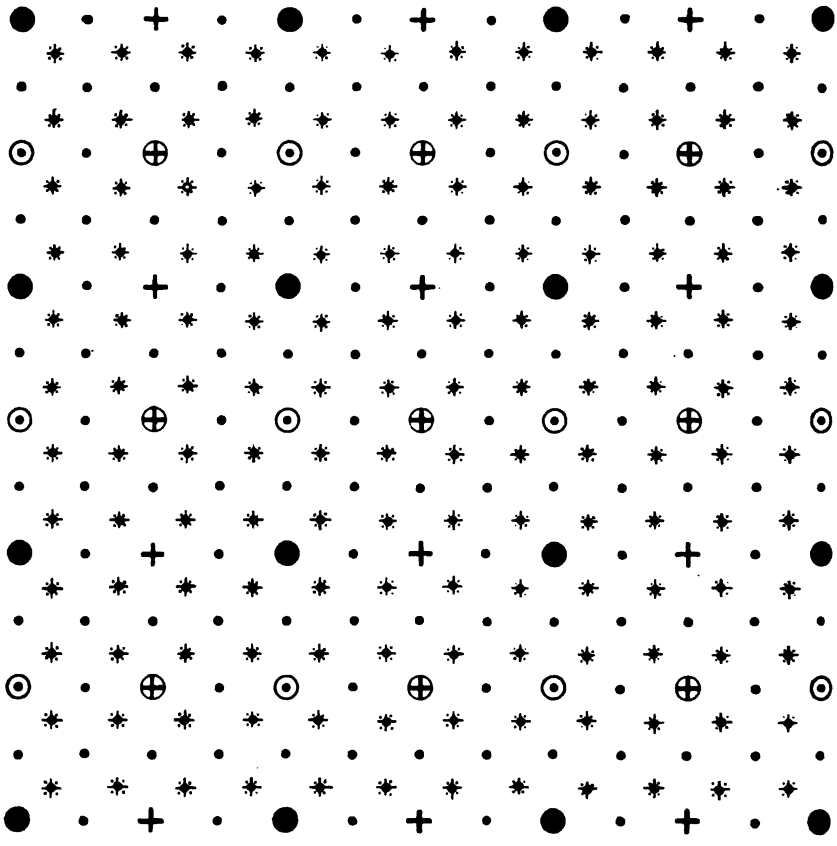
Formation and Tending of Mixed Woods of Broad-Leaved Species of Trees.—The tending of woods formed of broad-leaved species of trees requires considerably more attention and practical knowledge than the management of coniferous woods.

In Pine, Spruce, Silver Fir, or Larch woods, the trees are all of a decidedly upright habit of growth, and occupy a smaller individual growing-space; but in a plantation consisting of mixed broad-leaved species, the various kinds of trees all exhibit their own peculiar sylvicultural characteristics. Some incline to ramify horizontally (Elm), whilst others develop a strong upward tendency (Ash); hence much attention is necessary, especially during the first thirty years, in order to preserve a due balance, and to prevent the inferior species of more rapid initial development from overtopping and injuring neighbouring trees that may be of greater ultimate value as a crop. It is especially during the younger stages of growth that mixed plantations may be tended well or otherwise; for, unless the forester be well acquainted with the rates of growth in height of the different species forming the crop, he cannot possibly adopt such measures of treatment either in forming the woods or in tending them as will be most favourable to their healthy development.

In Britain the usual method of forming mixed forests is that of dispersing them mathematically and regularly over the whole area as indicated in the Diagram on next page.

Each species of hardwood is planted in such a manner that every two trees of the same sort are exactly 24 ft. apart. The author considers this an important point in the planting of mixed hardwood plantations, for it may ultimately be found necessary to cut out the whole of one sort; and in this case, those left will stand at equal distances after these have been removed. The Ash and Sycamore are planted within 12 ft. of the Oaks, while the Elm is nearly 17 ft. from them; this is another point of much importance to attend to in the

British method of planting mixed hardwood plantations. Supposing, for example, that the Oaks planted at 24 ft. apart are intended to remain as the ultimate crop, then Ash and Sycamore, which are of an upright habit of growth in a close wood, may continue to grow for a longer time along with the Oaks than the Elm, which is of a spreading



Oak-trees planted at 24 ft. apart, as represented by ⊙
Ash-trees, planted at 24 ft., " " ●
Elm-trees, planted at 24 ft., " " +
Sycamore-trees, planted at 24 ft., " ⊕
Larch nurses, planted at a little over 4 ft. from hardwood, as represented by *
Scots Pine nurses, planted at 6 ft. from hardwood, " " •

habit, could be allowed to stand. Hence the Elm, at nearly 17 ft. distance from the Oak, would at 30 years of age influence the growing-space of the Oak quite as much as the Ash and Sycamore although these stand nearer. The Larches are planted a little over 4 ft. from the hardwood plants; for the Larch, from its light habit of growth, is

found not to overshadow the hardwood plants so much as Scots Pine would do at the same age, and on this account the Scots Pines are for the most part planted 6 ft. from the hardwoods. The Larches, being next the hardwood, are likely to be taken out first in the way of thinnings; and in this case they are of far greater value when cut at an early stage than Scots Pine. The four Larches planted next each hardwood may be all removed in the way of thinning before it is found necessary to cut out any of the Scots Pine; hence the Scots Pine may be allowed to remain till they become of some value as thinnings.

One weak point in this system of forming mixed woods is its ignoring the practical fact that on any area of considerable extent there are usually variations in the nature of soil as regards depth and productive capacity. Hence it makes no endeavour to utilise these to their best advantage, as can only be done by forming mixtures in groups or patches. And, as has been previously remarked, the Scots Pine would be out of place on land of sufficient quality for the growth of Oak, Ash, Elm, and Maple; the Beech would be the proper tree to plant instead of the conifers. Another weak point is that too much importance seems to be attached to the realisation of revenue from early thinnings of Larch and Pine. As also previously remarked, when these species are used as nurses, they should be treated as such only, and should be cut out immediately when no longer required; for then they prejudice the development of the hardwoods. If young Larch and Pine poles form the most profitable crop, then crops of these may be grown. But it is not true economy to attempt in the above manner to kill two birds with one stone. If the hardwoods are to be the object of cultivation, then all other operations should be subordinated to their interests and their finest development; and it is impossible that these can be secured by allowing them to be overtopped for a few years by conifers of more rapid growth during the younger stages of development. In the formation of mixed woods (see *Studies in Forestry*, 1894, chap. vii.), it is a rule that the species of trees forming the ultimate main crop should either be of more rapid growth than the matrix, or should have the advantage in age and height, and should be carefully kept of advanced growth by means of clearing and thinning.

At what stage of the growth of such a young plantation should thinning commence? Altitude and other local circumstances must be taken into consideration. If the ground planted be upon a level part of the country, the trees will grow more quickly than they could do in a hilly district, even supposing the altitudes of both to be the same; while, again, trees grow much faster in a glen or hollow than upon a very common level piece of ground, and faster in a large plantation than in a small one. And with regard to soil, when it is of a light or sandy nature, young trees grow very quickly; while, at the same altitude, upon a heavy or clay soil, trees will be longer in developing.

To attempt to give anything like a rule for the exact time, measured in years, at which a young plantation should be first thinned is practically impossible, and could only be misleading. Wherever the main species of

trees—in this instance Oak, Ash, Elm, and Sycamore—require tending, the true sylvicultural treatment is to cut out the Larch or Pines (which seem to be out of place in such woods), no matter whether they will realise good returns or not; it is the health and development of the hardwoods that ought to be considered first of all. If the Oak or Ash, the most valuable species, be threatened with regard to growing-space and to the necessary supply of light and air by any of the other kinds of trees, these should be lopped or cut back, or even cut out; and this treatment may in some cases be necessary in four or five years, though in others perhaps not for eight or ten, or even twelve or fifteen years, according to the rate of development of the several species on the given soil and situation.[1]

In the tending of plantations generally, and more especially in the case of those in which it is desired to produce a supply of various kinds of hardwood for the general market, instead of any particular species remaining as an ultimate crop upon the ground, the forester requires to give them constant attention, in order to maintain the various species in healthy development. The crop must not be allowed to become crowded, neither must it at any time be thinned so severely as to interfere with the productive capacity of the soil, as is so often the case in Britain.

The time at which the tending operations of cleaning and of thinning should begin, and the extent to which they should be performed, depend, in the first place, on the density of the crop. And on this point it may be said that close planting, even though it may cost more both in forming the plantations and in the early unremunerative operations of cleaning, is on the whole preferable, with a view to the ultimate value of the crop, than wide planting, which delays the formation of close canopy for several years after it would take place under the former circumstances. Whether 4840 plants are put out per acre at 3 ft. by 3 ft., or only 2722 at 4 ft. by 4 ft., makes a very considerable difference as regards the early operations of tending; and when, with larger transplants, the distances are comparatively greater, the formation of close canopy is of course considerably delayed, and consequently also the operations of tending in the way of cleaning and thinning. As so much importance is attached to the thinnings, with respect to the subsequent growth and development of sylvicultural crops, the poles or trees to be removed should be selected and marked by the forester personally; and this operation must on no account be left to workmen.

As in deciduous woods it is only whilst all are in leaf that it is possible to have a correct idea of the extent to which the individual trees interfere with the development of their neighbours, it accordingly follows that the marking of the poles or trees to be removed should be undertaken in late summer, or in early autumn before the leaves begin to fall, although

[1] Curves exhibiting the average rate of growth of different species of trees will be found in *British Forest Trees*, 1893, p. 40, and in Schlich's *Manual of Forestry*, 1887, vol. i. Tending operations are, of course, necessary whenever a more valuable species is likely to be overtaken in growth and thereafter prejudiced in development by any less valuable species. These curves, taken from Heyer's *Waldbau* and other sources, exhibit the average rates of growth in Germany. They are therefore only approximate and subject to correction as regards Britain; but in general they indicate the ages at which particular attention is most likely to be required in given cases of mixed woods.

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Fig. 231.

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Fig. 232.

Thinning-knife, for making a double mark.

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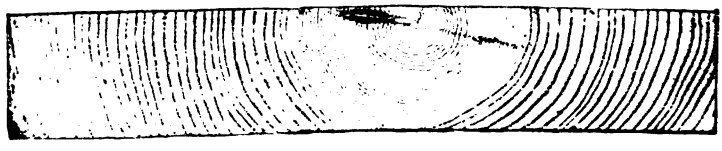
for the first time during the fifteenth to twenty-fifth year of their growth, and crops of Beech, Hornbeam, Oak, Spruce, and Silver Fir from the twenty-fifth to fortieth year. Reductions in the number of individuals during the thicket-stage of growth, until the natural process of elimination begins, are included in the operations of weeding and cleaning."

From this it will be seen that, so far as thinnings are concerned, as contrasted with the other similar and preliminary operations of tending which involve outlay and therefore enhance the cost of formation of the woods, the state of the local market must play a very important part from the financial point of view. Hence, as Sylviculture is based on purely economic and financial principles, a study of the conditions of the local market and its probable future determine not only the species of trees to be grown, and the initial density which should be given to the young crop, but also affect most immediately and directly the time at which weedings and cleanings give place to thinnings, and the extent to which these assist in reducing the initial costs properly chargeable against the particular crops under consideration in any given case.

In the great majority of cases of British woodlands, the time at which thinnings may begin will, except in outlying districts far from populous centres, be considerably earlier than the periods named in the above quota-

Fig. 233.



tion from Gayer. Thus Larch poles from ten-year-old plantations are usually of saleable dimensions, being about 10 to 12 ft. in length and from 2 to 3 in. in mean diameter at the middle.

Effects of Thinning. — When trees are cut down on attaining maturity, the life-history of the stem may often be plainly read by studying a section of the trunk. After each time of thinning there is a very marked enhancement of the annual increment, distinctly noticeable in the increase in the breadth of the annual zones or rings of wood (Fig. 233). Whilst the trees are competing keenly for food-supplies from the soil and for light and air, the new zones of woody fibrous tissue annually added to the stem gradually sink in direct proportion to the limitation of the individual growing-space. But when this struggle is terminated by a judicious use of the axe, the annual rings at once become much broader, and the increment throughout the whole crop may often be proved to be considerably greater than it was before the thinning, notwithstanding the fact that it is confined to a smaller number of trees. And this quantitative enhancement is at the same time accompanied by a qualitative improvement in the value of the crop.

The advantages of thinning are thus summarised by Gayer (*op. cit.*, p. 557):—

"1. It unites within it all the operations of tending young woods, and forms a valuable means of treating not only the whole crop, but also its various component parts or species, in the manner that seems most desirable for the benefit of the proprietor.

"2. Well-performed thinnings stimulate the growth and development of

the main or ultimate crop, and enhance its production in timber. For it is a fact proved by experience that a higher total production is effected by a certain reduced number of stems in energetic growth than by any superfluous number of stems of less energetic vegetative power.

"3. The influence of thinnings on the total production stands in direct connection with the effect produced in hastening or delaying the point of time at which the current annual and the average increments culminate or attain their respective maxima.

"4. The thinning can exert a very considerable influence on the quality of the timber produced. Hence operations must be carefully conducted and performed, in order that the quality of the timber may not be prejudiced by efforts made principally with a view to enhance the annual production of wood.

"5. By the removal of the stems no longer requisite for, or perhaps even prejudicial to, the development of the main crop at a time when they can still be utilised advantageously, a considerable *revenue* may often be obtained. Although data concerning such special returns do not belong here, yet it may be remarked that, in general, such preliminary or intermediate returns form on the average about 20 to 30 per cent. of the total yield of the crops.[1] But, in the interest of the main crop, a warning must be given against the danger of prejudicing its normal development by removing a portion of the crop prematurely in order to obtain larger returns in the way of thinning.

"6. In thinning, all dry and sickly poles and stems are removed from the crops, which are thus freed from the class of material most likely to engender *insects*, *fungoid diseases*, and *fire*.

"All these advantages of thinning necessitate prudence in the operations and a due weighing of all the concrete conditions in each case; otherwise the fellings may finally prove more prejudicial than beneficial to the ultimate development of the crop."

In marking the trees that are to be removed during thinning operations, this should be done upon one side, as the marks on the stems will then be more readily noticeable by the woodmen who have to cut them out afterwards. Unless the trees are all marked in this manner, time may be lost in searching for them, and stems may get overlooked here and there.

After the trees have been all cut out, freed from their branches, and stacked on the path or track at the edge of the wood, they should be removed by means of a horse and cart (or sledge), and stored in any convenient part until disposed of. If they can be sold beforehand, so much the better, as by this means considerable trouble will be saved in cartage and storing.

Arboriculture is not hampered by the same conditions as Sylviculture with regard to thinning. There, thinning may take place with a free hand, so as to ensure greater beauty of crown and foliage. In thinning out trees intended for park and lawn scenery, care should be taken that picturesque openings be made here and there as vistas towards distant objects seen from the mansion, such as

[1] Compare *British Forest Trees*, 1893, p. 24, for more detailed data.

a particular plantation upon a height, a romantic view of an old ruin, or a sheet of water in a neighbouring hollow. All of these are beautiful objects in landscape scenery, and should never be hidden from the mansion and grounds of the proprietor; for however beautiful trees may be by themselves upon a lawn, they form but a dull and monotonous scene if well-chosen glades are not left here and there, through which other interesting objects can be made visible.

Thinning of Woods formed of Coniferous Species of Trees.—As in the case of mixed broad-leaved trees, so also with regard to mixed coniferous crops can no particular age be given as that at which thinning operations ought to commence in young plantations. Here, likewise, the observations of the operator or forester must always be the guide in each case. On particular soils and situations a young plantation may be in a fit state for thinning at 8 years of age; while another, composed of the same sorts of trees, and planted at the same time, may not be ready for this operation at 10 or even 12 years' standing; but much depends on the elevation of the situation, the nature of the subsoil, and also the extent of the plantation itself. Hence observation upon the spot is the only decisive way of ascertaining when a plantation is in want of being thinned, or to what extent the operation is advisable.

With a view to ascertaining if Pine and Larch plantations require thinning, it is necessary to walk through their whole extent and note their general condition. If the points of the lower branches of the young trees be merely touching, or slightly interfering with one another here and there, thinning would be premature, and ought to be put off for a year longer; but if, upon examination, the lower side branches of the trees have the appearance of having been somewhat hindered in growth by want of light and air, and if the higher branches of neighbouring trees are interfering mutually with the normal development of the crowns, then it is time that thinning should be undertaken. If the lower branches of the young trees have a brown and deadened appearance, and the upper branches are spreading so widely that in many instances the points of the strongest reach nearly to the stems of others, thinning has been delayed too long. Again, thinning should never be delayed so long as to let young poles be drawn up in the struggle for predominance to such an extent as to make the stem insufficient to support the crown when the necessary thinning is carried out. In the latter case danger from snow, wind, &c., becomes greater than under other circumstances.

If, for example, the plantation consists of a mixture of Pine, Larch, and Spruce intermixed regularly according to the usual British method, and in about equal numbers, then in all the different parts of the plantation the thinning should principally remove those species

which do not seem to be thriving so well as the others; whilst that species should be favoured which seems, under the given conditions of soil and situation, to hold out the fairest promise of yielding the best monetary returns without endangering the productive capacity of the land. In each part of the plantation that species should be favoured which, from its general appearance, seems most likely to succeed best; and those species should first of all be removed which have not the appearance of developing good marketable stems.

In the thinning of young mixed plantations of Pines, Larch, Spruces, and Silver Firs the **light-demanding** Larch and Scots Pine will, of course, require to be assisted to a greater extent than the thicker-foliaged Black Pines; whilst the **shade-bearing** Spruces and Silver Firs will remain longest in close canopy without being ultimately prejudiced in development by the greater density of canopy. Early thinning is therefore desirable in the case of **Larch and Pine**; and when young poles are easily disposed of, the thinnings will usually succeed the cleanings and weedings at about ten or twelve years of age. But even in remote highland tracts, where small material can find no suitable market, tending operations of this description should not be delayed longer than the twentieth year in any case, more especially in districts subject to heavy snowfall, which is apt to do considerable damage to the brittle Scots Pine. The operations should be conducted gradually, and repeated at intervals of every three to five years at first. With the natural tendency that Larch and Pine crops have for thinning themselves after once they have passed through the pole-forest stage of development, the necessity for artificial thinning disappears, unless a partial clearance seems advisable for the purpose of underplanting with Spruces or Silver Firs with a view to stimulating the standards to more rapid increment in girth.

For crops of **Spruces and Silver Firs**, all distinctly classifiable as shade-bearing species, the operations need not begin so early. Where the later costs of cleaning are likely to be considerable, owing to there being no local markets for young thinnings, the operations may be delayed until about the twenty-fifth to thirtieth year, without affecting the development of the crop. It is more especially from the twentieth to the thirty-fifth years, during which the average annual rate of growth in height culminates (*British Forest Trees*, p. 36), that assistance should be given to nature, so as to shorten the struggle in which the energy of growth is frittered away to a greater extent among shade-bearing species than in light-demanding crops, where the dominated stems more quickly become suppressed. The thinning of Spruce-woods must, of course, be conducted more carefully in localities exposed to heavy winds or deep snowfall than in sheltered situations, where windfall and snow pressure are less to be feared.

No **pruning** of Pine, Larch, or Fir trees should be allowed; for pruning invariably deteriorates the quality of the wood of such trees, and their health may also be much injured by the entrance of fungoid spores at the wound-surfaces. If the trees are kept somewhat close to each other, they naturally clear themselves of branches as they advance in height; for, when the crops are maintained in normal density of canopy, the lower branches gradually die and fall off,

without forming knots that may materially injure the quality of the timber. Wherever the operation will repay itself, all the ends or snags of dead branches, however, should, as soon as they become lifeless, be carefully removed from the stems of conifers, because this tends to make the quality of the wood much finer.

As in the case of broad-leaved species of trees, so also with conifers,—it is always better to thin frequently, and take out a fewer number of trees at a time from any given plantation, than to thin at distant periods and then to conduct the operations severely. After any young plantation has been thinned for the first time, it is best to go over it again and to take out a few trees in the way of thinning at intervals of three years—regard being, of course, given to the species of tree, the nature of the soil and situation, the stage of development, and the concrete condition of the crop. By this gradual and only sound method of thinning, plantations never experience any sensible check, and consequently they are kept in a normal process of development; whereas, by the method of thinning at irregular intervals and without system, they are generally allowed to stand unthinned too long, and thereby the trees in a plantation are frequently permanently prejudiced to a greater or less extent from the effects of confinement to a growing-space below that required for the normal vegetation of the given species of tree.

Such evil effects will be more quickly observable in Larch and Pine than in Spruce or Silver Fir; and at the same time they will be more lasting in the former than in the latter. These results are only the natural and logical consequences of the relative demands of the various species of trees for light.

Every mixed coniferous plantation ought to be gradually thinned as the trees advance in height and breadth, until the crop is from 45 to 50 years of age, after which period the only operation of tending requisite will be the taking out of injured or unhealthy trees.

Pruning Operations.—There are many conflicting opinions as to the advisability of pruning forest trees. Much of this diversity of opinion arises from want of knowledge of vegetable physiology, and from improper methods of pruning. Every branch that grows out of the main body of a tree, and bears a flush of foliage, is by nature meant to act as a laboratory for the assimilation of the sap, and the formation of the nourishment requisite for the production of woody-fibrous tissue. Hence, when any branch is cut off from a tree, a deliberate interference is made with the balance naturally existing between imbibition by the root-system, and assimilation by the crown of foliage. This must always be the case in pruning operations. But, when they are performed judiciously, they constitute

only a very slight interference, not amounting to a disturbance of the normal process of vegetation. They may, therefore, as in the case of thinning, prove an assistance to the more gradual operations of nature, and of advantage to the development and timber-producing energy of the crop.

The analogy between Thinning and Pruning is very close. They are both operations performed with the view of assisting the more gradual work of nature. Just as, in the case of crowded crops, the less energetic stems are dominated, and finally suppressed and killed, owing to want of light under the shade of the crowns of the predominating individuals, so also, in the case of the lower and internal branches of the crowns of trees, a certain proportion of the sap is tapped on its upward course, drawn into the lower and inner branches, and there assimilated in a less thorough manner than would be ensured were it operated upon only by foliage in the enjoyment of a fuller supply of light. By thus eliminating the superfluous lower branches, the assimilated sap is utilised chiefly by the upper portions of the bole, and a relatively smaller proportion of it finds its way down to the base of the stem—*i.e.*, the annual zones become relatively broader at the top of the trunk than at the butt-end, and this makes the bole more valuable for ordinary technical purposes; for, of course, the utility and market value of timber depends very often on the size of square that can be obtained from it. Hence a full-wooded 40-ft. trunk having a top-diameter of 27 in., with a butt-diameter of 33 in., would be far more useful than a stem of equal length having a diameter of 36 in. at the base, and only 24 in. at top, although both would contain about the same number of cubic feet of wood.

But wherever timber crops have received proper sylvicultural treatment with regard to the normal density of crop, and to tending throughout all their different stages of growth and development, no pruning of high-forest crops is necessary. Such a measure is only requisite in order to retrieve a position lost through faulty management of the crop during the younger stages of growth; and even then, for purely financial reasons, the operations of pruning must be confined only to the more valuable species of trees.

The removal of dead branches, *i.e.*, the mere cleaning of the stems, does not interfere in any way with the vital energy of the tree. It is, on the contrary, of great benefit in obviating the formation of hard knots, which prejudice the technical quality of the wood. As is, however, remarked with regard to the conduct of pruning operations in the editor's *Studies in Forestry*, 1894, chapter ix. pp. 203–209:—

"The removal of living branches is, however, a direct interference with the vital condition of the growing tree, and can therefore only be ventured on to a limited extent. Under no circumstances should more than one-third of the total quantity of foliage be removed at one time; practically only about one-fifth of the foliage is generally the extent removed during such operations. Experience has shown that, even in the case of quick-growing species of trees, the removal of living branches should, ordinarily, be confined to those not over 2½ in. in diameter for conifers, or under 4 in. in the case of broad-leaved species of trees. Otherwise the process of cicatrisation cannot take place quickly enough to ensure hindrance of the germination of fungoid spores producing disease."

Experience has proved that wound-surfaces on conifers are much less able than the surfaces of hardwoods to offer resistance to the penetra-

ious kinds of rotting diseases. And
r of different species of forest-trees
summarised in the following extract

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peration; but as Ash and Alder both
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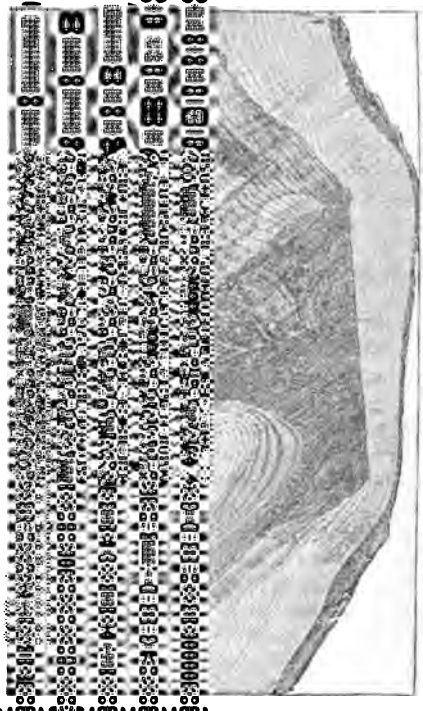
234.



nical and financial value of the stem,
Oak, exposes the tree to the danger
oods,—Birch, Willows, and Poplars,—
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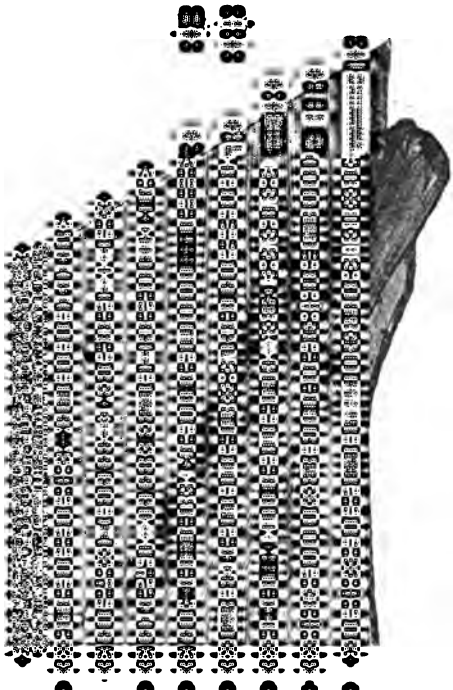
the disease-producing spores."

, in his *Theory and Practice of*

be the maxim of the forester. Plant
and leave the rest to nature. But, un-

[illegible] always thins constantly; [illegible] so a maxim, one of the [illegible]ed. Hence pruning may [illegible]st submit because of the [illegible]eless."

[illegible]fore especially in coni- [illegible]eavy snowfall, pruning [illegible]spared for the purpose. [illegible]ed crops more particu- [illegible]thinning of the lower [illegible]nopy to be maintained



[illegible] operations merely were [illegible] importance with regard [illegible]hich attain their sylvi- [illegible]y early age.

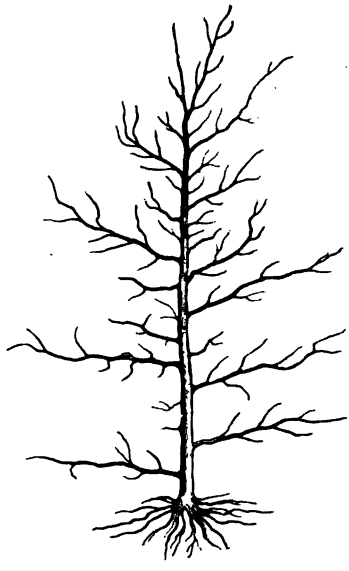
[illegible] branches and removing [illegible] The former of these [illegible] Oak, and the latter the [illegible]en pruned about thirty

[illegible] young trees have been [illegible]n, little or no pruning [illegible] trees grow vigorously

upwards, with perfect leaders to each tree and comparatively small branches. Where pruning proves necessary, it is generally found that the soil is neither of the description nor in the condition necessary for the healthy growth of the species; and in all such cases the cause lies in the bad management of the planter in the first instance. Where the trees are planted in a soil in all respects favourable to their growth, pruning is never found necessary to any considerable extent.

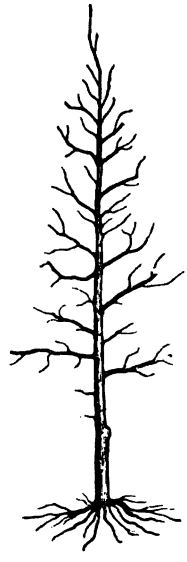
Trimming of Transplants.—Many foresters are in the habit of closely pruning all young hardwood trees, particularly Elms and

Fig. 236.



Natural growth.

Fig. 237.



Pruned condition.

Oaks, when they are taken from the nursery and about to be planted in the open; but it is most injurious to the health of all young trees when newly lifted from the ground. The injudicious system often practised is to cut off all strong branches, and only leave a few small twigs near the top of the plant, with the view of drawing up the sap. The natural consequences are that, when the sap ascends in the plant in the spring, it is arrested at the wound where the first or lowest branch was taken off, and has a tendency either to "bleed," or to produce young shoots and leaves at this point; and this effort at recuperation is often carried so far as to result in the death of the top part of the plant.

The proper manner of treating the transplants, as they are lifted from the nursery preparatory to planting them out, is to shorten all the larger branches that have the appearance of gaining strength upon the top or leading-shoot of the young tree. This shortening of the larger branches ought to be done in such a manner as to leave only about one-half of their whole length remaining, with, if possible, a few small twigs upon each, in order the more readily to elaborate the sap as it rises in the spring. This trimming will in general give the young stems of sturdy transplants a pyramidal form of crown (as in Fig. 237), which exhibits a young Oak properly trimmed, from its original condition (as shown in Fig. 236). Where two leading-shoots contend for predominance (as in Fig. 236), the side-shoot should be pruned off. In this state the young trees may be planted with the greatest assurance of success. The great advantage of this method of pruning young trees is that, when the sap rises in them during the first summer after planting, from there being a regular supply of small proportionable branches along the main stem, leaves are formed, and sap is drawn up regularly to every part of the tree; consequently the tree maintains an equal vigour throughout. Were all the branches left upon the young trees, the roots, from the effects of removal, would not be able to supply the whole with due nourishment; and the consequence would very likely be that the plants would generally be much checked in their growth for the first season or two, and that some of them would either be killed outright, or would die down to the ground-level, from which part of the trees numerous young shoots would issue, much in the same manner as they do from the cut part of those trees which have been over-pruned.

Fig. 238.

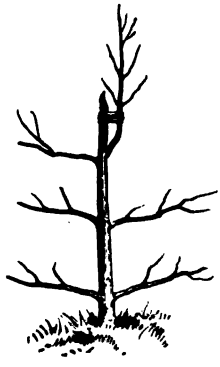
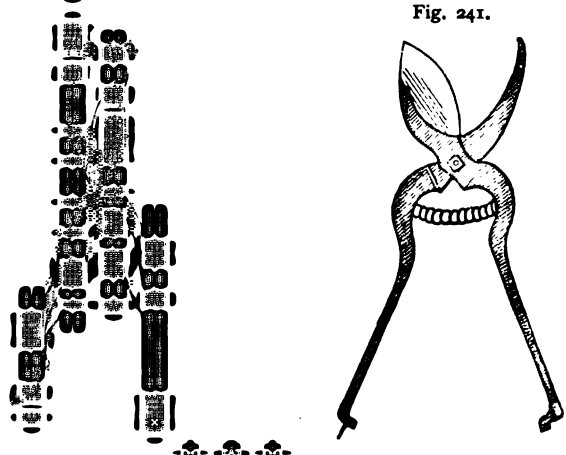


Fig. 239.

Trimming may sometimes even be necessary whilst the transplants are being schooled in the nursery. Thus, when the leading-shoot gets damaged or weakly from any cause, it may sometimes be necessary to train up a side-shoot to take its place; and this is done by the removal of the leader, and tying up the side-shoot, as shown in Fig. 238. Again, where flexures or bends in the stem occur, they may be finally remedied by pruning in the manner shown in Fig. 239, which exhibits a young Oak under treatment.

[illegible] lower twigs of seedlings being

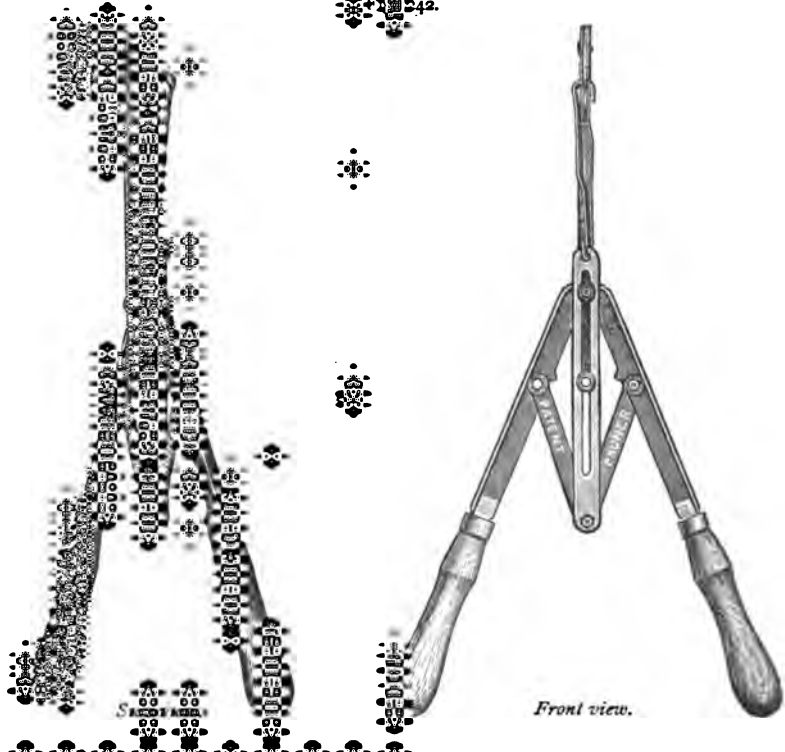
Fig. 241.



Pruning Shears.

[illegible] or of transplants lifted from these

Fig. 242.



Side view. *Front view.*

[illegible] the use of the pruning-shears is

to be recommended. From the one blade of the instrument being concave and the other convex, the shears clasp the twig firmly at once; and by a very slight effort one is enabled to cut it through, although it may be somewhat strong. They may either be made with only short metal handles, or else with wooden handles of any convenient length.

Another very useful instrument made by the Standard Manufacturing Company, Derby, and belonging to the class of pruning-shears, is the **Myticuttah** (see Fig. 242). The *modus operandi* is simply that the steel hook, within which the blade works, is placed over and holds the branch steady whilst it is being pruned. By pressing the levers steadily together a smooth even cut is obtained without having bruised the bark. It is specially convenient for trimming Holly and Thorn hedges, and other dense-growing trees, shrubs, and bushes of a prickly character, in the cutting of which, even if gloves are used, it is difficult to keep the hands and wrists from getting lacerated.

Pruning Implements.—In the pruning of all young trees whose branches can be reached from the ground and are not more than 1 in. in diameter, the work ought to be done with the common forest **pruning-knife** (see Fig. 243). The pruning-knife is not made with a hinge between the blade and the handle, as is the case in common pocket-knives; but the blade is fixed into the handle. The blade is also made straight in the face, *i.e.*, without any hook at the point, as is the case with garden-knives. When not in use, this knife is worn in a sheath of leather hanging at the side. In using the pruning-knife, the operator takes hold of the branch with his left hand a little forward from its base, so as to ease it upwards; and at the same moment he applies the pruning-knife with his right hand to the base of the branch to be cut off, cutting it upwards in the same line as the stem of the tree, and taking care to commence cutting about a quarter of an inch from the base of the branch. By this means the stem of the tree is not injured, and at the same time the rain is thrown off the wounded part. The wound should be made perfectly smooth, by being pared neatly all round with the knife, which should be kept very sharp. When the work of lopping off a branch is finished, the part will have the appearance represented in Fig. 244 at *a;* and in the course of two years after being removed, the wound-surface should be entirely cicatrised, or covered over with young wood.

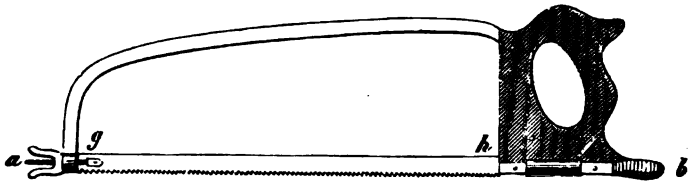
Fig. 243.

Fig. 244.

When pruning operations are performed upon strong poles, or trees whose branches may be within the reach of a man standing upon the ground but are too large for being easily cut off by

the pruning-knife, the **pruning-saw** is used (Fig. 245). In this the movable blade *gh* can be adjusted to any given angle by means of a handle *b*, whilst the saw can be loosened and tightened as shown at *a*. In all cases of pruning off a branch with the saw, care must be taken, first of all, to make a slight cut with it upon the under part of the base of the branch to be taken off, say from ½ to ¾ of an inch deep if the branch be 3 in. in diameter. This is in order to prevent the branch, when nearly cut through, from falling down, so as to tear away the bark below its base upon the stem, and thus open a wide door for the entrance of disease-producing fungoid spores. Care

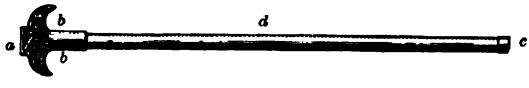
Fig. 245.



should be also taken to pare and smooth with a sharp knife all the rough wound-surface, and to coat it over with tar or other waterproof antiseptic substance. By attending to this, damp will not be so apt to lodge upon the wound, nor will the risk of fungoid infection be so great, as otherwise must be the case.

Another very useful instrument is the **pruning-chisel** (see Fig. 246), the handle of which, *d*, may be of any convenient length to suit the height of the tree to be pruned, and should always be made of well-seasoned Ash-wood. In using this instrument, the

Fig. 246.



operator takes hold of the pole with his left hand, and puts the sharp face of the instrument, *a*, to the under part of the base of the branch. He then with a mallet in his right hand gives one or more strokes upon the lower end of the handle, *c*, which has an iron **ferrule** or ring upon it; this forces the instrument through the branch, and thus separates it from the stem of the tree. In doing this, care should be taken to repeat the strokes lightly when the branch is nearly cut through; because, were a heavy stroke of the mallet given at this time, the instrument might be forced upwards, so as to injure the stem of the tree by making a deep cut. When it is necessary to take off any

ng and not in balance
ment, *b b*, are used.
n taking off any part
instrument suddenly
nch may be cut very
-chisel a good deal of

48.

Fig. 251.

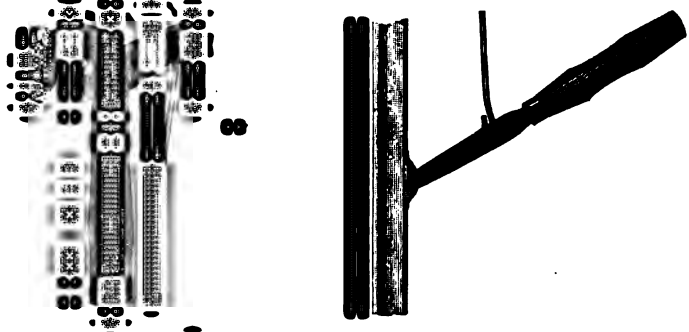
249 to 251, *Pole-Saws.*

tised workman it is a

the **Aerial Combina-**
mpany, St. Alkmund's
rm of pruning-chisel,
t classes (Figs. 247 to

[illegible] ctures another pruning instru- [illegible] r (Figs. 252 and 253), for use [illegible] trations exhibit both ends of this [illegible]

Fig. 253.



[illegible] struction. It consists of a pole, [illegible] The hook is of steel, and is made [illegible] the hook. The knife is thus [illegible] sides, and can be made very [illegible] cing the resistance of the wood, [illegible] an and smooth cut. The knife [illegible] and operated upon by, a metal [illegible] a great degree of power; whilst [illegible] being encircled by the hook, [illegible] er the control of the operator, [illegible] until the portion to be removed [illegible] whole is very light and easily [illegible] e had with any length of pole. [illegible] (Fig. 254), is a similar descrip- [illegible] mply consisting of shears worked [illegible] pole by means of a lever-handle [illegible] s attached for the purpose of the [illegible] the handle in the act of cutting [illegible]. The pole of the averuncator [illegible] any convenient length to suit [illegible] rformed, so that by its use twigs [illegible] to a height of 25 or even 30 ft. [illegible] Cook, & Ridal, of Sheffield.

[illegible] performed either during the late [illegible] erproof coating gets better fixed on [illegible] r owing to the wound-surface being [illegible] ntiseptic waterproof coating becomes [illegible] wound from fungoid spores entering [illegible] ing," or loss of sap from within.

As was pointed out by the author in the fifth edition of this work (p. 565), where it is desired to utilise the bark for tanning purposes, Oak-trees should be pruned in June; but, from the sylvicultural and true economical point of view, the only proper time for pruning is the season at which the sap of the stem and branches is at its very lowest ebb, *i.e.*, in the late autumn and early winter.

And the same principle holds good here as in thinning generally. It is far better to prune slightly and repeat the operation within a year or two afterwards, if necessary, than to try and correct the errors of past tending by one severe operation; because in this latter case, if the operation be carried so far as to create any disturbance in the organism, there is a danger of "stag-headedness" owing to the development of adventitious buds along the bole of the tree.

Tending of Ornamental Woods of Broad-leaved Species of Trees.—The condition of trees in ornamental plantations of about sixty years of age will depend altogether upon the treatment they may have previously been subjected to. If they have been regularly tended and systematically thinned, they should, by the time they are about sixty years of age, be fine, healthy, well-developed trees. But if they have been allowed to grow up in somewhat close canopy, they will probably have a greater length of stem, with a weaker development of crown, owing to the limitation of their individual growing-space.

Where trees have been properly attended to, from the purely **arboricultural** point of view, and have been thinned frequently and freely whilst still young, that is to say, between the ages of 15 to 40 years, they are little likely to show signs of weakly growth during any of the subsequent stages of their development. But where, on the other hand, they have been neglected while in their young stages, no after-treatment, however judicious, can be relied on to secure for them the full beauty of outline and shape that might easily have been attained by essentially **arboricultural** treatment during the earlier period of their existence.

Assuming that plantations of the broad-leaved species of trees, grown for the express object of ornamenting the park and its neighbourhood, have been tended and thinned freely to the age of sixty years, the only after-treatment necessary is to clear away from time to time any inferior specimen, whenever it clearly seems to interfere with or encumber a better tree to which it may be contiguous, or whenever its removal may bring any very fine specimen more prominently into view, or may open up a desirable vista from any particular point of observation.

The only good way of endeavouring to improve a neglected plantation, which it may be found desirable to retain as long as possible in order to preserve the amenity of the neighbourhood, is to single out all the most healthy and promising trees in it, and gradually to relieve them from the competition of all such inferior stems

as interfere with their enjoyment of light and air. This must, however, be performed only gradually and with judgment, as any sudden removal of a large number of the inferior individuals may have the effect of producing stag-headedness, or perhaps breakage from wind; and this would, in either case, prove the ruination of the whole. But even with careful attention to, and judicious application of, this rule, much of the ultimate success of the operation always depends upon the selection that is made of the trees for standing before thinning commences; because if only weakly-rooted trees are left, with comparatively heavy tops, the operation can never be relied on to succeed, as there is always more or less of danger from stag-headedness among broad-leaved species.

An ornamental plantation of trees managed on the purely arboricultural principle of allowing every tree in it to stand well clear of any of its neighbours at all stages of its growth, always remains more ornamental, and attains a greater age, than crops managed on purely financial and sylvicultural principles.

Tending of Ornamental Plantations of Conifers.—Although large masses of Pine, Spruce, and Silver Fir are generally objected to in the immediate neighbourhood of residential seats from their too dark and sombre effect, they are not objectionable in any undulating and hilly district when grown on hill-tops and higher slopes at some distance. From their evergreen foliage and their massive appearance at all seasons of the year, they in such positions give the landscape a grand effect not attainable by broad-leaved species of trees alone; hence plantations of evergreen Conifers are often maintained on extensive properties solely with a view to their being ornamental, independent of the quantity or the quality of the timber they may produce.

In training up plantations of evergreen Conifers, whether mixed or pure, with the view to ornamental effect, the trees should, at all stages of their growth, be kept much farther apart from one another than when trained up for the sake of their timber alone, in order that they may have full opportunities of developing into handsome stems with comparatively full crowns of foliage. Except when standing in isolated positions, however, no attempt need be made to keep them so far apart as to cause the individual specimens to become of an extremely rough and branching habit, but only to give them sufficient growing-space to ensure that their crowns will not be interfered with. This requisite individual growing-space differs, of course, with the various species of trees, but may generally be secured by keeping the stems apart at distances nearly equal to their average height.

If ornamental coniferous plantations are trained up in this way till they have attained fifty years of age, they will require very little

individual attention in the way of thinning afterwards; for the trees will, with such a free growing-space, have become generally well-developed specimens, and will therefore only require to be occasionally relieved here and there, as a few of the largest individuals may want more space for the greater spread of their branches, or as an inferior stem now and again may show a tendency to disease of any sort, or perhaps to encroach on or interfere with a better. This will usually be all that is necessary to maintain the health and beauty of evergreen coniferous plantations after about fifty years of age, provided, of course, that the trees have been gradually accustomed to free exposure to currents of air, so that danger from windfall is not probable. As such crowns of foliage are more equally developed round the stem, they are less liable to damage from snow or ice than smaller crowns in woods of greater density.

When such plantations have been neglected while young, so that the trees have become drawn up, there is little hope of their recovery by any system of after-treatment. Where, however, the limitation of the individual growing-space has not been very great, the recovery will be in proportion to the recuperative power of the species. Practical experience shows that equal degrees of neglect in broad-leaved and in coniferous plantations are attended with very unequal measure of recovery afterwards. Although a broad-leaved crop may have been much neglected, it will be improved greatly if skill be applied to thinning it; while an evergreen coniferous plantation of the same age, and equally neglected, will often not only fail to improve, but may, on the contrary, deteriorate the more quickly when thinning is attempted. Therefore, when it is found desirable to improve a neglected Pine or Fir plantation, more judgment is necessary for success in the work than in the case of a hard-wooded crop.

The explanation of this phenomenon is to be found in the larger reserve of nutrients in the broad-leaved species. The comparatively small stores of starch in evergreen conifers are probably utilised so quickly in the formation of new foliage and twigs as to become exhausted before the root-system has time to extend, so as to yield the full food-supplies and water requisite to meet the larger demands of the foliage for assimilation and transpiration. (See also the remarks on this subject at vol. i. p. 477.)

To improve a neglected plantation of coniferous trees, the same mode of gradual thinning should be followed as has already been recommended in the case of broad-leaved plantations. When, however, the trees, even under gradual thinning, do not seem to improve within two or three years after it has been commenced, the best thing is usually to clear them altogether and to replant. But very much of the success attending the thinning of neglected plantations of any

sort will be found to depend upon whether or not the land is naturally well suited to the given species of trees.

Tending of Sylvicultural Crops of Broad-leaved Species of Trees.—It is worth noting, with reference to the difference between raising crops of broad-leaved trees with a view to ornamental purposes and treating them on purely financial and sylvicultural principles with the object of producing timber for sale only, that in the case of the latter less growing-space is necessary for each individual pole or tree, as large tops and branches are not compatible with either the production of the maximum quantity of timber per acre, nor with the formation of clean boles of the highest technical and marketable value. The **normal density** of such crops will, therefore, at all stages of their development, be considerably greater than in the case of crops treated arboriculturally.

In the management of sylvicultural plantations of mixed species of broad-leaved trees of considerable age, the more spreading species, like Ash and Elm, must not be allowed to interfere with the individual growing-space of Oak in particular, which is easily injured by confinement.

Although a greater number of trees may be grown in sylvicultural crops than when grown mainly for arboricultural or ornamental purposes, still great caution and judgment are necessary in order that the crop may not become so crowded as to interfere with its finest development; because, under such circumstances, the trees become drawn up too rapidly without attaining the due and normal proportion naturally existing for purposes of stability between the height and the girth of the stem. Much of the value of the crop, in fact, ultimately depends upon whether the trees are allowed sufficient space to develop themselves healthily during all the various stages of their growth. The only sound rule that can be given for guidance in this respect is to allow each tree merely a sufficient space for the healthy action of only a moderate crown of branches and leaves, but not to give so large an individual growing-space as may encourage the spread of the branches at the expense of the stem, or may prolong the life of the lower branches to such term as may prove prejudicial to the technical and marketable value of the bole.

This **normal density** of canopy is, of course, dependent on the relative demands for light made by the different species of trees, as has previously been intoned by the editor throughout many previous parts of this work. It will be greatest and most marked in **light-demanding** species like Oak, Ash, and Birch, and least in Maple, Sycamore, Hornbeam, and Beech; and it will be greater on fresh fertile soils than on poor dry land.

Tending of Sylvicultural Crops of Conifers.—The most valuable description of coniferous timber being that which is most free from

branch-knots, and of the greatest top-diameter and length of stem, it is necessary to keep the trees standing sufficiently close to each other to check ramification without prejudicing their healthy vegetative energy. Throughout all the younger stages of growth a normal density—short of crowding, of course—stimulates growth in height, and enhances the quantity of timber produced in the stems. With respect to Larch and Pine, however, great caution is necessary in order to avoid the opposite extreme of crowding the plantations, and thereby deteriorating the crops both with regard to quantity and quality of the timber produced.

Such normal density varies, of course, with the species of tree and the nature of the soil and situation. Thus, on the classes of land most favourable to the development of each species, the normal density of pure crops throughout Germany is on the average (*British Forest Trees*, 1893, p. 43):—

Age in years.	Silver Fir.	Spruce.	Scots Pine.
40	1375	1053	727
60	529	509	377
80	316	317	244
100	223	240	171
120	175	224	141

And again it has been shown that (*Studies in Forestry*, 1894, p. 188):—"As regards the influence which the species of tree has on the extent to which thinnings are necessary, Schuberg (see Gayer's *Waldbau*, 1889, p. 550) found in the Black Forest that in 40- to 80-year-old crops, which had been regularly thinned, the following were the results on soil of average quality:—

	Scots Pine.	Spruce.	Beech.	Silver Fir.
Average number of stems per acre .	545	619	686	864
Absolute individual growing-space in square feet	80	70	63	50
Relative individual growing-space .	100	87	79	63

In the management of pure Pine plantations upwards of fifty years in age, comparatively little attention is required other than the removal, from time to time, of such inferior trees as are found to interfere with the further development of the more promising stems; for by that time the trees will have completed their main growth in height, and will gradually begin to broaden in crown whilst thickening the girth of their stems so as to form good marketable boles.

If the coniferous plantation be large, and the land favourable to

the rapid and healthy growth of the trees, there is a great tendency of the crop to become crowded and drawn up too rapidly. When this is the case, thinning should be moderately and frequently repeated to a later stage than would be necessary under an opposite condition of the crop.

To show the practical and financial utility of judiciously checking the growth of the branches of coniferous trees, in order to favour the production of a finer quality of timber in the stems, it may be stated that, taking any two trees of equal dimensions, the one of a rough and branching habit of growth, and the other with a smooth and clean bole, the timber of the latter would be at least of 50 per cent. greater value than that of the former. This must, of course, make a vast difference on the total value of crops of considerable extent.

The Larch requires even more growing-space than Scots Pine for the spread of its branches in order to attain its finest development. No tree is, in fact, more easily injured than the Larch by confinement; therefore at all stages of growth it should be allowed ample space for the spread of its lightly-foliaged and loose crown. From inattention to this essential condition many plantations have been rendered comparatively worthless that might, had they been dealt with according to a study of the natural requirements of the Larch as the most light-demanding of all coniferous trees—or indeed of all of our sylva, except perhaps the Birch—have been of very great value to their proprietors. It would, however, be equally ruinous from a financial point of view if the trees were allowed to stand too far apart from one another, in order to attain any superfluous ramification or coronal development. Such a course would result in a great loss both of quantity and quality in the crop produced. What is meant is, that the normal density of the crop should not exceed the limit which tends to interfere with the vital energy of the individual trees forming the crop. This normal density of the crop is easily maintainable under prudent management with regard to systematic cleaning and thinning during the earlier stages of development, also by judicious attention to relieve the crowns of side-shade after once the trees have completed their main growth in height, and till they attain maturity.

The Practical Effects of Underplanting.—By the term **underwood** is implied all woody-fibrous plants growing under standard timber-trees. It may consist either of shrubs like Dogwood, Buckthorn, Privet, Rhododendron, Holly, &c., or of stool-shoots issuing from the stumps of trees which have been cut down in thinning. In one or other of the above forms underwood may generally be found in plantations wherever the growing crop of timber-trees is not maintained in full normal density of leaf-canopy. Under certain systems of management (see **Copse**, vol. i. p. 515), the underwood is specially treated

in a rotation of its own, with a view to the realisation of the best returns available. Plantations of rather small extent, more particularly if upon exposed and high-lying situations, are much improved both in quantitative and qualitative production of timber by having a well-regulated quantity of underwood growing beneath lightly-foliaged trees, so as to protect the productivity of the soil and enhance the increment of the standards.

So far as ornamental underwood is concerned, the following species of shrubs and other plants may be recommended for cultivation on the different classes of soil named against them:—

Name of species.	Nature of soil in which they thrive best.	Name of species.	Nature of soil in which they thrive best.
Aucuba japonica .	Any dry loam.	Yew-tree . . .	Sandy loam.
Laurel bay . . .	Do.	Arborvitæ, American	Do.
Broom	Do.	Butcher's broom .	Do.
Box-tree . . .	Do.	Elder or Bourtree	Do.
Dogwood . . .	Do.	Guelder rose . .	Rich loam.
Ivy	Bare rocky parts.	*Mahonia aquifolia*	Do.
Holly	Rich loam.	Cotoneaster . .	Any dry loam.
Hornbeam . . .	Do.	*Philadelphus* . .	Do.
Laurel	Do.	Snowberry . . .	Do.
Privet	Do.	Spindle-tree . .	Do.
Sloe and Blackthorn	Do.	Spiræa	Do.
Laurustinus . .	Do.	Hazel	Do.
Rhododendron .	Peat soil.	Hemlock spruce .	Do.
Juniper	Very light sandy soil.	*Pinus pumilio* .	Do.
Sea-buckthorn .	Do.	*Pinus inops* . .	Do.

The above list contains all the most important shrubs for ornamental underwood. Hornbeam, Hemlock Spruce, *Pinus pumilio*, and *P. inops* have been added, because, from their spreading habit of growth, they are well fitted to produce excellent cover. Dogwood, Elder, Guelder rose, Sloe, Spindle-tree, Sea-buckthorn, Philadelphus, Snowberry, Spiræa, and Hazel are deciduous plants, whilst the others are all evergreens. In planting any of the sorts named, with the view to produce shelter upon any exposed point, the Elder, Hazel, and Pines usually prove most hardy. Where it is wished to cover any bare rocky part in a plantation, with the view of forming cover for game, and of producing an ornamental effect at the same time, Ivy, Juniper, Yew-tree, and Hazel should be planted, as all these thrive well in such situations; and where general groups of underwood are wanted, whether in the body of plantations or along the sides of roads, the other sorts may be used.

The common system of planting ornamental underwood is to scatter the individual specimens promiscuously among the trees, without any regard to order; but this is neither ornamental nor useful.

Though done generally with the view of producing cover for game, it is seldom that the plants so dealt with grow well enough either to form a good cover or to be ornamental. Where underwood is wanted in the interior of a plantation, either for the purpose of cover for game or for ornament, groups of Laurel, Bay, Holly, Portugal Laurel, Hemlock, Spruce, and Privet, keeping each kind separately in a mass by itself, may be planted out in patches of about one-sixteenth to one-eighth of an acre, wherever the light and broken canopy of the standards is most favourable to their continuous thriving. The more purely ornamental low-growing species, such as Rhododendrons, Cotoneasters, Philadelphus, Snowberry, Spiræa, Mahonia, Roses, Laurustinus, and Aucubas, may be kept next to the rides; and in order that a natural variety may be produced by the plants of each species being congregated in a mass, two or three Arborvitæ may be put in as prominent plants in a group here and there, especially among the deciduous sorts, so as to produce a pleasing and graceful effect. Again, in some cases, a tree growing in the centre of such a group might be clothed with Ivy, as this also has a graceful effect in a wood.

The Sylvicultural Importance of Underplanting, with a view to the enhancement of the increment of timber crops when approaching maturity by means of protecting and increasing the productive capacity of the soil, has already been adverted to in describing the sylvicultural characteristics of the various species of **light-demanding trees** like Oak, Ash, Maple, and Sycamore (chap. ii.), Larch and Scots Pine (chap. iii.).

The most advanced modern Continental system of enhancing the increment in such light-demanding crops is to thin them very severely, by means of what is technically termed a **partial clearance**, which removes one-fifth or more of the crop, and then to underplant the standard trees in order that one of the very first fundamental principles of Sylviculture may not be violated. This measure can, of course, only be financially successful when the crop has still sufficient energy of growth to be capable of being stimulated; for crops that have already sunk into the preliminary stages of over-maturity or senile decay, the system is not applicable.

This artificial diminution in the number of stems per acre deliberately endangers the productive capacity of the soil, by exposing it to the injurious influences of sun and wind, unless measures be adopted to underplant the standards with some **shade-bearing and soil-protecting** species like Beech, Hornbeam, Spruces, or Silver Firs. For, as is well expressed by Gayer (*op. cit.*, p. 571):—

"Whenever the partial clearance is likely to lead to interruption of the canopy of the crop, it should only be carried out when the productive capacity of the soil is such as promises in all its essential factors to supply continuously the increased demands made in consequence of greater energy in the crown of foliage (transpiration and assimilation), *i.e.*, that the land in question is fertile, or that care may be taken to stimulate the productive capacity of the soil in some suitable way at the proper time. This can only take place through the maintenance of a good layer of humus and the careful retention of soil-moisture, and consequently in many cases only by means of **underplanting** in order to protect the soil against sun and wind."

Detailed information cannot here be given with regard either to the scientific aspects of the question of partial clearance and underplanting, or to the practical effects of such operations in general; but the attention of students is drawn to the editor's *Studies in Forestry*, 1894, where each of these special subjects has a chapter devoted to it. So far as the scientific investigations of the Forestry Section of the Faculty of National Economy in Munich University have proceeded, however, the conclusions arrived at up to date are the following (Nisbet, *idem*):—

"It has not yet been shown that the undergrowth exerts any direct and immediate influence on the increment of the light-demanding standards; but it undoubtedly does improve the shape of the bole, and consequently its financial and technical value, as well as the quality of the timber, at any rate in the case of light-loving Conifers. Again, by increasing the quantity of fallen leaves and needles, and by preventing them from being blown away by winds, it essentially favours the production and direct increase of humus, and thereby materially affects the physical properties of the soil and stimulates its productive capacity.

"Oak, Larch, and Pine are the species extensively grown in pure forest which stand most in need of underplanting when once they have completed their main growth in height and begin to make larger demands on growing-space. The other light-demanding species, like Ash, Elm, Maple, and Sycamore, should be less frequently grown in pure forest than in patches in mixed woods, where the ruling species, generally the Beech, protects the soil against deterioration. Shade-bearing species require no undergrowth. Unless maintained in close canopy they tend to branch-development and consequent reduction of the form-factor of the bole with diminished monetary and technical value; whilst it is only on the best qualities of soil that Beech, Spruce, or Silver Fir can thrive for any length of time under the dense shade of parent standards forming anything like a full canopy.

"Whether the underwood should be formed by sowing or planting depends in each case on local circumstances. Sowing is in the majority of cases much cheaper; but it takes longer to attain the object in view. Planting can be easily carried out, wherever practicable, with seedlings from neighbouring woods, or with 2 to 3-year-old seedlings or transplants from temporary nurseries, and should not amount to more than about 15s. per acre if put out from 3½ by 3½ to 4 by 4 ft. apart by means of notching. Even should the costs of underplanting be higher locally, the advantages of the method are still cheaply obtained where the intention is to produce the most satisfactory monetary returns from pure forests of Oak, Larch, or Pine, that are unable of themselves to protect the soil against deterioration, but which it is not desirable to clear away yet for the formation of other crops of timber. Many an Oak-grove in England, and many a Larch and Pine tract in Scotland, would yield far more satisfactory returns from every point of view—financially, sylviculturally, æsthetically—if due measures were taken for the protection and improvement of the productive capacity of the soil by means of underplanting after thinning or slight clearance, and treatment thereafter in accordance with the rational principles of the science of forestry."

Tending of Hop-Pole Plantations.—Poles for supporting hops in hop-fields are procured partly from coppice-shoots, partly from thinnings of young plantations reared with a view to timber, and partly from crops of various sorts of trees, planted and reared expressly for the purpose. In all cases the price obtainable varies according

to the durability of the kind of wood and the size or length of the poles.

Shoots of Oak, Sweet Chestnut, Sycamore, and Ash are all used for the purpose when found of suitable lengths in coppice-woods; but as poles of such species are of a soft and perishable nature, they do not fetch the same market-price as Larch poles, which last much longer. Scots Pine is also used for this purpose; but Larch is in most cases preferred to any other wood.

As Larch is found to yield the most profitable description of hop-poles, this species should be given the preference in such plantations on all land suitable to its growth.

There are two modes of growing Larch for hop-poles, viz.: (1.) to plant the young trees at distances varying from 18 to 30 in. apart, according to the size of poles wanted, and to let them grow undisturbed till they are of the size wished, when they are all cut over and disposed of at once; or (2.) to plant the young trees at 18 in. apart, and, when they have arrived at a stage suitable for the smaller size of poles, to thin out each alternate tree, and leave the others to grow for some years, until they attain the larger sizes. Either of these modes may prove financially the more advantageous, according to the class of poles that may be found most in demand in the locality.

In Wolmer Forest and its neighbourhood large quantities of young Larch are reared for this purpose. They are there planted, some in fields at 18 in. apart, others at 20 in., others at 24 in., others at 30 in., and others at about 3 ft. apart,—all depending upon the character of the poles it is wished to grow, whether of a small size or of larger dimensions; of course the smaller the poles are wanted, the closer the trees are planted.

There is no class of tree-crop more simple of cultivation than this, for the only object is to obtain the largest number of clean, straight poles producible on the given area; and this is attained by planting the young trees closely, in order that they may draw up one another to the desired length.

The land should be trenched at the outset, so as to stimulate the young trees to more rapid growth, in order to make them fit for the market about two or even three years earlier than if they had been planted on unprepared soil; and of course from this a very decided financial advantage is gained, notwithstanding the fact that some outlay is necessary for the soil-preparation. At each time of replanting the land it should be trenched to a depth of 18 in.; and all the Larch roots should be grubbed out, so as to prevent attacks of beetles and weevils by removing the material usually selected by them as breeding-places.

On inferior, light, sandy, and gravelly soil in the south of

England, similar crops of Scots Pine are also grown for hop-poles on land of too poor a description for the thriving of Larch. As the Scots Pine grows well on poor soil, such crops often pay well, even although a smaller price is given for Pine poles than for Larch. In fact, the poorest land possible may be converted into profitable bearing by raising crops of Scots and Black Pines on it for this purpose, as it is not necessary they should be grown to a size larger than 3 in. in diameter (see footnote to vol. i. p. 6).

Tending of Coppice-Woods.—The tending of coppice plantations is a branch of forestry which perhaps requires least theoretical knowledge in the forester. Excepting Oak-coppice, this kind of sylvicultural crop is seldom cultivated in Scotland; whereas in England it is very extensively cultivated, and forms in many counties a large proportion of the woods, particularly in those inland counties where fuel is scarce.

All coppice-woods must, in the first instance, be raised either naturally from seed, or else artificially by means of sowing or of planting. The young crop ought to stand till the shoots attain a thickness of from 5 to 6 in. diameter at the ground; this may be at about 12 to 20 years of age, according to the species of trees planted and the nature of the soil and situation. In order to convert any plantation of young broad-leaved trees into coppice, it is only necessary, when they have arrived at the above dimensions, to cut them over close to the ground. During the following season they will either send up a number of young shoots from the stool, or of stoles or suckers from the surface-roots; and in either case these will constitute what is termed a coppice-wood.

All trees do not equally possess the property of sending up young shoots from the collar of the stock; therefore the choice of the kind of trees is to be taken into consideration by the grower of coppice-woods. The coniferous species of trees practically do not send up shoots at all when cut over; whilst Beech and Birch have not a very powerful reproductive capacity of this description.

With respect to the reproductive capacity of the different species of trees in this respect, the following details are given by Gayer (*Waldbau*, 1889, pp. 48, 49):—

"So far as concerns the portions of the tree from which the shoots are flushed most easily, they are chiefly those which have the thinnest corticeous covering, or are covered with the young bark. Such portions include the base of the stool, the collar or neck of the root, the cicatrisations of wound-surfaces either on the root-stool or the stem, all young stool-shoots, &c. The first essential for the development of stool-shoots or root-suckers is *the supply of light;* for stools that are deeply overshadowed, or otherwise deprived of light, either throw out no shoots or stoles, or else develop them only sparsely and indifferently.

"The species of trees which retain longest their reproductive capacity in this respect are Oak, Hornbeam, Elm, Common Alder, and Sweet Chestnut; whilst it is lost soonest in Beech, Birch, Maple, Sycamore, and Ash. Conifers have no reproductive power of this sort to speak of, or at any rate which may be utilised sylviculturally on a large scale. Next to the broad-leaved species of trees, in this respect, comes the Larch, and then the three-needled species of Pines. But having regard to those portions of the trees from which the reproduction principally takes place, there are likewise important differences between the various species of trees. Among those which *reproduce themselves principally from the stool* are comprised the Oak, Hazel, Hornbeam, Beech, Elm, Sweet Chestnut, Lime, Black Poplar, Common Alder, Ash, Maple, Sycamore, Field Maple, Willow, and Birch; Aspen, White Alder, Robinia, and Blackthorn *reproduce themselves principally by suckers or stoles from the roots;* whilst Willow and Poplar in particular, as also Lime, Elm, and Field Maple, possess the capacity of reproducing themselves *both by stool-shoots and root-suckers*, or from any portion of the stem."

The kinds of trees best adapted for coppice-plantations are Ash, Elm, Oak, Poplar, Willow, Chestnut, Lime-tree, Mountain-Ash, Maple, Sycamore, Birch, Alder, Hazel, and Bird-Cherry. These again, according to the uses they are generally applied to, may be divided into four classes, viz.:—

1. **Coopers'-ware and Bobbin-wood**—Ash, Mountain-Ash, Elm, Oak, Chestnut, Maple, Hazel, and Sycamore.

2. **Charcoal-wood**—Birch, Alder, Poplar, Lime-tree, Hazel, and Mountain-Ash.

3. **Bark for Tanners**—Oak.

4. **Basket-ware**—Osier-Willows.

In the above division of the kinds of trees best suited for coppice, firewood has not been included, because all woods may be employed for fuel purposes, although not with like effect, as Ash, Oak, and Birch are more useful than any of the other sorts; but as, in general cases, it is only the refuse of the coppice which is utilised as firewood, it seems unnecessary to designate any class exclusively for that purpose.

The above specification of Ash, Oak, and Birch as the most useful species for fuel is not in accordance with well-known experience throughout France and Germany, where Beech and Hornbeam are most in demand for domestic heating purposes. As Gayer says (*Forstbenutzung*, 1888, p. 81):—

"According to the every-day experiences made in the domestic use of fuel, the different species of wood, bulk for bulk, may be classified as follows with regard to their utility as firewood:—

"1. *Possessing greatest heating-power:* Hornbeam, Beech, Birch, Turkey Oak, Mountain Pine, Robinia, resinous old Scots Pine, Black Pine.

"2. *Possessing considerable heating-power:* Maple and Sycamore, Ash, English Elm, resinous Larch, ordinary Scots Pine, Oak.

"3. *Possessing a fair heating-power:* Scots Elm, Spruce, Silver Fir, Sweet Chestnut, Cembran Pine.

"4. *Possessing little heating-power:* Weymouth Pine, Lime, Alder, diseased Oak, Aspen, Poplar, Willow."

In laying out a coppice-plantation, it is necessary to consider well what sorts of coppice-wood will sell to the best advantage in the neighbourhood; and when this matter has been ascertained, the next consideration will be whether or not the area at disposal is of such a nature, with regard to soil and situation, as may profitably produce continuously the kind which is in best demand. To plant any species of trees on land not really adapted to their natural requirements as to food-supplies and moisture can never be true economy. Were Ash, Elm, Lime-tree, or Poplar, for example, planted upon a dry, light, thin soil, or Sweet Chestnut, Hazel, Mountain-Ash, or Birch on cold, stiff, binding land, then probably in neither case would profitable returns be harvested.

In localities where various kinds of coppice-growth are readily marketable, all bare hilly tracts, the soil of which is light and not more than a few inches deep, may be planted up with Birch, Mountain-Ash and Hazel, at about 3 ft. by 3 ft., so as to induce rapid development in height.

Upon the lower hilly tracts, the soil of which is of a somewhat deeper and better description, Maple, Sycamore, Oak, Chestnut, and a sprinkling of Beech may be put out at about 3½ ft. over all. But upon all the better portions of good loamy soil on uplands having an elevation less than either of the two former tracts, the most profitable crop will usually be a mixture of Ash, Elm, Lime-tree, Poplar, Chestnut and Oak, at 4 ft. apart, with a few Beech scattered here and there.

In planting the various species of trees in the different soils and situations above named, each should be grouped in patches by itself, as this has been proved by experience to be productive of more advantageous results than the admixture of the various species as individual plants in any more or less regular and stencil-like manner. Were Mountain-Ash, Birch, and Hazel, for example, all mixed together only individually in a coppice-wood, the Mountain-Ash, from being of a more rapid growth than either of the other two, would shoot ahead; soon, by overshadowing them, it would hinder their normal development. Each species of wood, therefore, which is meant to form part of the permanent crop, should be planted in patches by itself, wherever the soil is better suited to it than to any other species. When coppice plantations are conducted on the principle of growing each species in patches, they can be more conveniently utilised at different periods, according as special conditions either of the crop itself or of the market at the moment may suggest this as desirable. If any purchaser, for example, wishes a certain quantity of hoop-wood of a particular size, and is prepared to give a remunerative price for young Hazel that will meet his requirements, it will be much easier

for the forester to supply his demands when the crop is grown in patches of each species. At the same time the cost of harvesting is decreased, and the effects of the perhaps somewhat premature utilisation of the particular species, will not be attended with the same danger regarding reproduction as if the stools were scattered individually throughout the crop and necessarily overshadowed by the shoots of the other species left standing; for, as has above been pointed out, the reproductive vigour of the stools is materially diminished when an abundant supply of light is not available for their stimulation. The same may be said of Oak-coppice, as a purchaser would give much more per acre for a hag of pure Oak-coppice than for crops mixed with other woods for which he might have no desire at the moment.

In forming permanent coppice-woods, a decided preference should, so far as the nature of the land admits of this, be given to species of hardwoods known to be of value and in steady demand. And wherever nurses require to be planted for the purpose of producing a temporary shelter, they should not be evergreen species like Pines or Firs, but lightly-foliaged and hardy species like Birch and Larch, that will not be so apt to injure the main crop by heavy overshadowing. Such nurses should be cut out whenever they can be spared as no longer necessary for the protection of the main crop against frost, &c.

Sylvicultural Treatment of Coppice-Woods.—As, with the low period of rotation usual in coppice-woods, the soil is laid bare frequently, it is very necessary to take measures for safeguarding its productivity; and this is all the more requisite, the less fertile and fresh the soil may naturally be. The only economical and effective method by which this can be attained is by a judicious mixture of shade-bearing and soil-improving species, along with those of a more lightly-foliaged and light-demanding habit of growth. For all light or limy soils the Beech is to be recommended; whilst on moister land the Hornbeam yields good results in this direction. Within a matrix of one or other of these two species, the light-demanding kinds may most advantageously be grown in small patches. Thus, on loamy or limy soil, Maple, Sycamore, Elm, Lime, Oak, and Hornbeam often associate themselves naturally with the Beech, and by tending in the way of cleaning the young crops a good deal can be done, even without much sowing or planting, to obtain a favourable admixture of species; whilst on fresh sandy or mild loamy land the Softwoods (Birch, Willow, Poplar) usually spring up spontaneously to such an extent as to necessitate partial removal during the operations of weeding and cleaning.

In coppice-woods the Beech is at a disadvantage in comparison with the other species of trees; for it is naturally endowed with a less vigorous reproductive capacity of this description, and its shoots are not of such rapid development as those of most other species. So far as the general growth and outturn of Beech is concerned, this particular species yields better returns when growing along with Ash, Hornbeam, and Birch, on good fresh land, than under any other circumstances.

With reference to the characteristics of the various other species of wood grown in coppice, Gayer gives the following summary (*Waldbau*, 1889, p. 264):—

"Among the other species grown along with the Beech in mixed coppice-woods there is, of course, also a struggle for individual growing-space; but when the stools do not stand too crowded, when the soil is good, and certain Softwoods, apt to spread out horizontally, only occur in a very subordinate degree, then Ash, Maple, Sycamore, and Hornbeam, or on deep land the Elm, and on warm exposures the Oak, can maintain themselves well, more especially when some little assistance is given to them in the way of cleaning. The Ash in particular generally holds out well in coppice-hags on suitable kinds of soil, and even when its shoots are somewhat closely confined. But so soon as there is any considerable admixture of Birch, Lime, and Hazel—species prone to extend far horizontally at an early period of their development—throughout the crop, and the influence of these begins to exhibit itself in conjunction with the development of the stoles or suckers of Aspen, White Alder, Hawthorn, and other shrubs, which is rapid at first but soon falls off in rate of growth, then the previously named Hardwoods are exposed to the danger of being interfered with and finally suppressed; and this danger is all the greater, the less the soil and situation suit the normal requirements of the one or other of these species."

This very succinct and able *résumé* may not appear intelligible to foresters who have had no Continental experience; for it is a fact that, both in high-forest and in coppice, the crops are of considerably greater **density** on the Continent than in Britain. But the explanation is solely to be found in the differences in the fundamental principles of treatment, viz., **arboricultural** in Britain, and purely **sylvicultural and financial** on the Continent. The essential differences in this respect have nothing to do with climate; because, so far as **density of crops** is concerned, the advantage lies with us in having a more equably moist insular climate during the spring, summer, and autumn months, which is much more favourable to vegetation than the dry Continental climate during the annual period of vegetation. The possibility of having a higher and more advantageous standard of **normal density** for each species of tree and form of crop certainly rests, so far, in our hands.

In high exposed parts, where hardwoods are hindered in development by the effects of wind, about one-third of the whole number of the nurses per acre may be Pine, or in less exposed parts one-fourth; and where the ground is generally of a sheltered nature, the whole of the nurses may be Larch. But in such cases coniferous high-forest crops will usually hold out better financial promises than coppice.

In damp hollows or marshy land, where most broad-leaved species would fail to thrive well, Alder-coppice is often the most remunerative form of crop.

In raising young crops of coppice, weeding operations must be carefully attended to during the first three years of their age, in order to prevent the hardwoods in particular being choked by long grass, or other rank growth of weeds; and all nurses must be taken away as soon as their service can be dispensed with.

By the time the coppice-plantation is about 10 years old, the nurses should all be removed; and at 15 to 20, or even 25 years,

according to soil and situation, the first crop should be harvested, when the plants attain about 6 to 8 in. in basal diameter. At this size they will be of proper dimensions for cutting over for the purpose of being converted into **stocks** or coppice-stools.

The actual work of felling may be done in several ways (see Figs. 255, 256, 257). Fig. 255 represents the method of cutting over by means of the saw, and leaving the stock flat on the top. This method is open to the great objection that dew, rain, snow, &c., lodge on the flat top, and thus prepare the way for the entrance of fungoid spores,

Fig. 255.

Fig. 256.

Fig. 257.

which cause rot in the stool at an early age. Fig. 256 represents the stools cut in a sloping direction with the bill or axe, with a view to hinder the lodgment of water, and thus prevent rot taking place. The author objects to this method, because, in the cutting over of a young tree by repeated strokes from a heavy bill or axe, the stock is much damaged, and apt to be split longitudinally; consequently rot is sure to commence early. Fig. 257 represents the manner in which all stocks should be treated in order to maintain them sound and to produce a healthy crop of shoots.

The author's plan of preparing the coppice-stools was as follows:—

Have a young lad with a sickle, such as is used for cutting down grain, and cause him to go before the men who are to cut the trees, and to clear away all long grass, &c., from the base of each tree to be cut. This he should do to the distance of about 2 ft. all round each tree; and in doing this he must be made to cut the grass as short as possible, in order that there may be no obstacle to having the trees cut low. When the boy has got the first tree cleared at the base, two men with a light cross-cutting saw follow him. The saw should first enter upon one side of the base of the tree, which of course should be the side to which the tree is intended to fall; and having cut at least 2 in. through upon that side, and about 2 in. up on the base of the tree from the ground, they then take out the saw and cut the tree through from the opposite side.

The reason for not cutting the tree through with the saw from one side is, that when this happens to be done,—and it is too often done—and when the tree has just begun to fall, the bark upon the side of the tree opposite to where the saw was entered is liable to be torn away, with very often a part of the outer wood; and this will the more readily occur if there be a little wind blowing at the time—for it almost invariably takes place before the men have time to cut the part clean through. Now this evil can at once be avoided by simply cutting, in the first place, a part of the base upon the side to which the tree is to fall. In this manner the boy, with the two men following, will prepare and cut down the trees, observing to cut each stock so that it may be, as nearly as possible, about 2 in. high above the surface of the ground. Next in order, there will be required another man with an axe, whose duty is to prune the branches from each tree as it is felled. The branches, again, as they are cut off, are to be assorted for different purposes,

according to the local demand; and as this is done, they should be carried out to the nearest road in the plantation, and laid in convenient lots, each according to its kind, in order for sale. The trees, also, as they are cleared from their branches, should be carried out to the roads, and assorted according to their sizes.

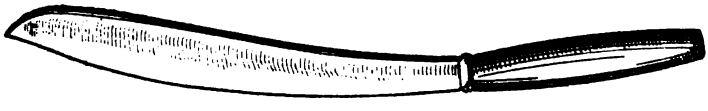
In this way the whole work of cutting down and carrying out the trees and their branches should be performed, taking care that the workpeople, in the act of carrying out the wood, do not put their feet upon the stocks; for by their doing so the bark would very likely be broken from the edges, which would of course be injurious to them. The work of carrying out the wood should therefore be carefully performed; and in order to see this done, a trustworthy man should superintend it.

The trees being all cut, and their produce carried away from a certain tract of ground, so that there need be no cause for apprehension of danger to the stocks, another man with a **sharp adze** will round the edges of each stock. In doing this, he must take care to go nearly down to the surface of the earth with the adze, paring with it both bark and wood, sloping it up neatly all round to the centre of the top of the stock. He must at the same time be most careful that the bark and wood have the same slope, for if this is not attended to, water may lodge upon the bark and cause rot there. He must also be cautious not to separate the bark from the wood.

There can be no doubt that the **trimming of the stools** with an adze is an excellent method of treatment. But it is costly in comparison with the method of felling by means of a sloping cut made with a heavy bill, which latter system is that in general use throughout the Continent. Where the stools are split, it argues want of deftness on the part of the woodmen, and forms a fault that may be corrected by careful instruction. It may here be conveniently remarked that the production of numerous coppice-shoots is stimulated by **deep felling**; whilst, in the case of those species that produce both shoots and stoles, deep felling stimulates to the production of the suckers in greater numbers than would otherwise be the case.

The Burmese "**Da**" (Fig. 258) would be an excellent instrument for felling coppice-woods. It is a long slightly curved blade, of about 18 in.

Fig. 258.



Burmese "Da" or Bill.

in length, and $\frac{1}{4}$ to $\frac{1}{3}$ of an inch in thickness at the back, fixed firmly in a rounded wooden handle of 9 or 10 in. in length, and which is made to swell slightly at the middle portion. It is a heavy and well-balanced **Bill**, which is a very effective and clean-cutting instrument. It is utilised by the Burman for everything in the way of cutting—from the whittling of a small toothpick up to the felling of the stems of giant trees over 3 or 4 ft. in diameter. The heavier forms of this instrument seem most admirably adapted for the felling of coppice-hags.

The work of harvesting the crops from coppice-hags ought to be performed by the proprietor's own woodmen, and not handed over

to contractors, as is sometimes done to the great detriment of the stocks, and consequently of the future crop of shoots. A really serious matter concerning the welfare of coppice-woods is the very bad practice that frequently prevails of allowing purchasers to harvest the crop for themselves. Both of these systems are very bad, but more especially the latter.

The most suitable time of harvesting coppice-woods is late autumn or early spring, when there is least sap in the crop. Felling during hard frost is apt to splinter and split the stools; but in the harvesting of Oak-bark (see Chap. XI.) or of Birch, when the rind is to be used for tanning, or of Alder, Hazel, and Mountain-Ash, whose bark has no bite (as a mordant), but whose wood requires to be stripped before being sold to the powder manufacturers, the felling must take place after the sap has begun to rise in spring. In all cases of making common charcoal for colour and paint-makers, it is not necessary to peel the wood for that purpose; hence, except for fine qualities to be used for gunpowder, charcoal is generally made from wood with the bark on.

As many foresters may have occasion to make charcoal for ordinary estate or household purposes, the following sketch of the author's method may perhaps be found useful:—

The wood being collected near the place intended for the operation, and cut into billets, usually about 15 in. in length, the pits, or stacks, are generally formed in this manner: A spot adapted to the purpose, of from about 12 to 20 ft. in diameter —according to the quantity required—is selected, and being properly levelled, a large billet of wood, split across at one end and pointed at the other, is fixed in the centre of the area, with its pointed extremity in the earth, and two pieces of wood inserted through the clefts of the other end, forming four right angles. Against these cross-pieces four other billets of wood are placed, one end on the ground, and the other leaning against the angles. A number of large and straight billets are afterwards laid on the ground, to form a floor, each being, as it were, the radius of the circular area. On this floor a proper quantity of brush or small wood is strewed, to fill up the interstices, when the floor will be complete. And in order to keep the billets in the same position in which they were first arranged, pegs or stumps are driven into the ground, in the circumference of the circle, about a foot distant from one another. Upon this floor a stage is built, with billets set upon one end, somewhat inclining towards the central billet; and on the tops of these another floor is laid, in a horizontal direction, but of shorter billets, as the whole is intended, when finished, to form a cone. The whole is then coated over with turf, and the surface generally plastered over with a mixture of earth and sand. Previous to the operation of setting fire to the pile, the central billet in the upper stage is drawn out, and pieces of dry combustible wood substituted in its place, to which the fire is applied. Great attention is necessary during the process in the proper management of the fire, and in immediately covering up any apertures through which the flame seems to obtrude itself, until the operation be concluded, which is generally effected in the space of **four or five days**, according to circumstances. When the charcoal is thought to be sufficiently burned, which is easily known from the appearance of the smoke and the tendency to flame no longer appearing

through the vents, all the apertures are to be closed up very carefully with a mixture of earth and sand. This, by excluding all access of the external air, prevents the charcoal from being any further consumed, and the fire goes out of itself. In this condition it is suffered to remain till the whole is sufficiently cooled, when the cover is removed and the charcoal is taken away. If the whole process is skilfully managed, the charcoal will exactly retain the figure of the pieces of wood.

The trees cut over in the months of February and March (excepting the species that have to be barked, which are cut in May or June) will, by the middle of June, have sent up a large supply of young coppice-shoots from the collar all round. In the autumn of the same year, the whole plantation thus cut over will form a coppice of one year's growth. Where it is intended to stimulate the growth of the individual shoots so as to form more valuable poles, such plantations should have each stock thinned at the end of the second or third year, so as to leave not more than four to eight of the best shoots upon each stool, according to the nature of the soil and the strength and general vigour of the stools. Such a cleaning or thinning should be made in every sort of young coppice; and where the small material can be easily sold for hampers and crate-making, considerable profit may sometimes be derived from these thinnings, without taking into calculation the improvement in the future crop both from the material and the technical points of view.

As to the period at which coppice-plantations should be cut over, no definite number of years can be stated as sufficient to bring them to a certain size, as so very much depends on the nature of the soil, situation, and local climate. For example, taking Oak as a standard for calculation, in Herefordshire coppice is as bulky at 10 or 14 years as it is in Argyleshire at 20 or 25 years. The best age for harvesting coppice-hags depends also essentially upon the demand for the crop. Thus, in some parts of England, where coppice-growth is used extensively for hampers, crates, and coopers' work, it is often cut over at 2 and 3 years of age; in other districts, where it is largely used for hop-poles, it is cut over at 5 and 6 years old; and in others, again, where it is principally used for fencing, and similar rural purposes, it is cut over at from 10 to 15 years of age. In Scotland, again, where Oak-coppice is chiefly grown for the sake of bark and spoke-wood, it is left till it is from 5 to 7 in. diameter at the base. But, at whatever age coppice may be cut over, the work of harvesting should always be done by the proprietor's own labourers, as that is the only satisfactory manner of securing the best treatment of the stools from the sylvicultural point of view.

By cutting close to the ground, not only is a better flush of shoots and of stoles secured, but the stools last very much longer, as they

are less exposed to rot from the action of wetness and fungoid disease. In order to renew old and worn-out coppice plantations, the only sure, effectual, and profitable way is to replant.

The Value of Coppice-Crops must in all cases depend greatly on the nature of the soil and situation, and also upon the management they may have received while in their young state. Save in the exceptional circumstances offered by a favourable market, high-forest crops are preferable to coppice-woods, for they conserve in a much higher degree the productive capacity of the soil. From the author's experience previous to the recent fall in the value of bark, 20s. per acre per annum was about the average return derivable from Oak-coppice; whilst Birch and Alder yielded on the average about 18s., and Ash about 30s. per acre. Coppice of a general mixed character he never found profitable, as it seldom realised more than 12s. per acre per annum. The above valuations are taken from coppice cut down at periods varying from 15 to 25 years. In Lancashire, even though there is a great demand for coppice-growth in Manchester and Liverpool, the land under such a crop seldom produces above 30s. an acre to the proprietor, while more frequently it merely yields from 12s. to 20s.; and that, too, in the case of land which, if put under good forest management for the cultivation of timber, would doubtless realise a considerably better nett annual return. Wherever such is the case, it would seem advisable to convert the coppice-woods into high-forest.

Conversion of Coppice-Woods into High-Timber Forest.—There are two distinctly different methods of effecting this object. That generally adopted on the Continent is to select the best-grown shoots and to leave them as **stores or standards** at the time of cutting down the coppice. Only as many good shoots are thus selected as can ultimately become timber-trees upon the ground; and these are left standing at distances of from 20 to 30 ft., whilst all the rest of the coppice is cut over to bring forth another crop.

The opportunity may at the same time be taken of introducing stout transplants of the more valuable species of trees, like Oak, Ash, Elm, Maple, and Sycamore, to form the ultimate crop, as seedlings possess greater longevity and develop better than stool-shoots, or even suckers, during the later stages of growth as high-timber forest.

In the author's opinion the only sure way of converting a coppice plantation into healthy standing timber is as follows:—

When the regular coppice has been thinned for the first time, say at two years old, have in view the raising of a regular portion of the best of the shoots for ultimate timber; and with this view thin out all the weakly shoots and such as are badly formed leaving none but the choicest, and those rather thinner upon the

stock than if the plantation were merely thinned with the intention of its remaining under coppice. Having thinned the coppice rather severely at two years' standing, at four years let it receive another good thinning, by taking away from each stock the worst of the shoots, leaving none but the best, and not more at that age of these than from four to five upon the most healthy of the stocks. At six or eight years of age give another regular thinning; at about twelve, a fourth; and at fifteen years there should upon no stock be left more than one shoot, which is designed to be trained up as a timber-tree. After this period, such a plantation may be treated exactly in the way which has already been directed for hardwood plantations. The advantages of this system are evident: (1.) The trees are trained up gradually and naturally, and never suffer any check; (2.) a better selection can be made, from there being a continual choice of shoots at the command of the forester as they grow up at different stages; and (3.) by this method of selecting and training up, the plants, or trees as we may term them, at nearly twenty years old will be about twice the size of others that are merely chosen from the body of a thick coppice-wood and exposed all at once. Hence, by the time that they are thirty years old they will be three times as large, and, it may also be added, three times as healthy and valuable.

The objection to this method is that it may frequently fail to secure that **density of crop** which is essential for the simultaneous protection of the productive capacity of the soil and the utilisation of this productivity to its fullest possible extent. It is, in fact, an **arboricultural** treatment of the crop, which cannot bear the full scrutiny requisite in purely **sylvicultural**, *i.e.*, **financial**, utilisation of the soil. In Sylviculture, gradual transformations from coppice into high-forest can be best effected by forming a kind of **copse** or **coppice under standards** first of all, and then increasing the number of standards grown from seed; for stoles and suckers do not hold out the same periods of rotation as crops raised from seed, and do not assume the same dimensions of girth or attain the same marketable value before commencing to sink in average annual increment.

As cases often occur where proprietors may wish to convert a coppice-plantation of some years' growth into a timber crop, it may be stated, for their guidance, that at whatever age they may wish to do this, they should never commence to cut down suddenly, and expose the shoots they wish to rear up as trees. The only sure way in a case of this kind is to select the very best of the shoots at proper distances from one another, and have them pruned and kept clear from the shoots upon the other stocks. Those also should alone be selected which appear to come away from the earth, and not those which have the appearance of coming away from the collar of the stock—for such never will form really good trees. As those that are made choice of advance in size, give them room gradually, and eventually good standing timber may be formed in this way by cutting away all the rejected shoots betimes, in the same manner as in the case of thinning away nurses from among young hardwood trees in any other timber plantation.

There are many districts in this country where coppice-woods are more remunerative, and even more ornamental, than high-timber

crops could be on the same sites; but where coppice-woods, growing on land adapted for high-forest, do not bring in a good return, it will generally be found more profitable to grow trees in the form of high-timber crops.

Formation and Tending of Copse, Coppice under Standards, or Stored Coppice.—This form of timber crop is common in many parts of the country, and of considerable importance upon many estates.

In the rules framed by James I. for the conduct of forest operations in the New Forest, it was laid down that "all timber trees are to be excepted, and all saplings of oak that are likely to make timber, and that twelve standels be left in every acre." But previous to that a proclamation had been issued in 1608 (Lascelles, pamphlet on the *Arboriculture of the New Forest*, 1893, p. 7) to the effect that as—

"Great spoils and devastations are committed within our forests, parks, and chases . . . we therefore have endeavoured to take course to stop the said abuses, and to work the means not only of the better preservation of our said woods in time to come, but of a present multiplication and increase of wood to all ages, and to the end that our care may appear to the preservation and increase of timber as well to others as to ourselves . . . we do straightly command and charge all our loving subjects in general that *in their own woods* they presume not hereafter to defraud the true meaning of our statutes by cutting and felling the young stores when they usually fell their underwoods."

Since legal pressure was thus brought to bear on the owners of woodlands at a comparatively recent date, measured by the standard of longevity of Oaks, it cannot be surprising that this form of woodlands has played so important a part in Britain. And more especially must this under any circumstances have been the case, when it is recollected how admirably this method of treatment was adapted to suit the growth of Oaks for naval purposes, as better trees and crooks would thus be obtainable than could possibly be grown in the close canopy of well-managed high-forests.

When crops of Oak and other Hardwoods are cut down for the purpose of converting them into a copse or coppice-wood under standards, the whole of the fall should be removed immediately, in order that no damage may be done to the young shoots as they arise from the stools; for, if the wood be allowed to lie long upon the ground after it is cut, the young shoots will have grown to a considerable height, and they, being extremely tender, will be easily broken in the act of removing the poles at a later period. In order to prevent this, the purchaser of wood felled in the winter-time should be bound by the articles of sale to have all the produce removed by the middle of June at latest. If this be not done, the after-crop of coppice-shoots will be almost certain to be more or less damaged. And the work of extraction should always be done by the proprietor's own workmen.

In order to prevent the lodgment of water between the bark and the wood of Oaks, the author considers that it is always a good plan to employ a man to go before the woodcutters, and, with a handbill and wooden mallet, cut the bark

right through to the wood, in the form of a ring, all round the circumference of a tree, fully 2 in. above the surface of the ground. The first ring being cut all round, another should be made in like manner 2 or 3 ft. higher up on the bole of the tree, when the piece of bark situated between those two cuts can be removed, and the woodmen made to saw each tree across exactly by the lower mark, or bottom of the peeled wood. This forms a guide to the men not to injure the lower part left with the bark upon it, as well as, when any difficulty is experienced in bringing the tree down, avoiding all waste of bark.

As soon as the wood and bark have been removed, all useless underwood should be carefully cleared away, excepting any young healthy shoots or plants which may be considered worth leaving upon the ground, with the view to their ultimately becoming trees. Immediately after the ground has been cleared, the stocks of the trees should be adzed in order to cause the young shoots to flush as near to the roots as possible. If the young coppice-shoots be allowed to proceed from that part of the old stock which rises 2 in. above ground, these shoots will always partake more of the character of branches than of trees, and never will make a valuable plantation; but if forced to proceed from the collar or part of the stock where the roots join with the main stem, and which lies immediately under the surface of the soil, they will partake of the character of trees, and will become independent of the parent stock by sending out roots of their own, which will materially assist in their subsequent development. In using the adze, care must be taken that the part where the roots issue from the main stem be not injured. The sooner the operation of adzing is done after the trees are cut, the greater is the chance of obtaining a good crop of healthy shoots. The forester, therefore, ought not to delay this until the work of clearing away the trees be finished; the whole ought, indeed, to be proceeding simultaneously. One way of conducting operations of this kind is to have a party of men with horses and carts, who begin upon one side of the ground, and clear away all the valuable wood as they proceed. Immediately following this first party comes a second, consisting of women and boys, headed by a man to superintend them, who gather up all the brushwood left by the men with the carts, carry it to convenient openings, and burn it at once, unless some other more economical use can be made of it. When the ground has been cleared by this second party, the adzemen follow and dress the stocks.

If the stalks of the trees cut down are not numerous, as is more than likely to be the case if the trees were of any considerable age,[1] there will not be nearly enough for a permanent crop upon the ground. If, for instance, they were eighty years old, there will not be more than from 60 to 70 trees to the acre. Now, to have a piece of woodland with only that number of stools per acre would never prove remunerative; therefore a crop of young Oak or other hardwood trees should be planted out wherever there are blanks between the stools, so as

[1] "Chestnut, Oak, Hornbeam, Elm, and Alder retain the capacity for reproduction longest; Beech, Birch, Maple, Sycamore, and Ash lose it soonest. . . . Recent experiments conducted by M. Bartet at Nancy show that Oak and Hornbeam are capable of producing stool-shoots up to 60 or even 85 years of age" (Nisbet, *British Forest Trees*, p. 52).

It must, however, be remarked that, as the flushing of stool-shoots is not a natural effort at regeneration, but at reproduction of injured parts, the recuperative power becomes weakened when once the individual tree has entered fully into the seed-producing stage. Hence only those stems can yield good crops of shoots which are cut back to the stool whilst still in the full energy of development.

to fill up the whole to distances varying from 4 by 4 ft. to 5 by 5 ft. On suitable land it adds to the remunerativeness of the crop to sprinkle a few Larches here and there among those hardwoods that are not so light-demanding as Oak and Ash.

When the young coppice-shoots have been allowed to grow undisturbed for two years, they should be cleaned by having all small and weakly shoots removed, thus only leaving the strongest. These selected shoots should be left for other two years, when a thinning should be made, so that only the strongest and healthiest shoots are again allowed to remain; and in no case should more than six shoots be left to stand permanently upon any individual stock, or fewer still if the stool seems in any way wanting in vigour.

When the young shoots have thus been cleaned and thinned, they may at the same time receive a judicious pruning. And when they grow up, any Larch that have been planted out in blanks should be thinned away gradually in order to make room for the hardwoods as they develop.

As a wood of this description grows up, the shoots from the old stools may be treated either as coppice or as timber, along with the planted trees, as may best suit the object of the proprietor. Many proprietors cultivate coppice of this description along with trees in their plantations, with the view of making cover for pheasants; and for this it answers admirably. In such cases the coppice growth is treated arboriculturally, for it is intentionally kept low and of a spreading habit by the shoots being headed down to a certain height, while the planted trees are trained up as timber above them. But the coppice is thus rendered of little economic value. Where sylvicultural treatment of the crop is the object, this plan of dealing with the coppice should not be adopted. In all cases where coppice is mixed with planted trees, and where it is desirable to obtain the highest nett returns from the land, the best way is to thin out the weaker portion of the shoots as the crop gradually develops, and to leave ultimately only the very best on each stock to attain the dimensions of trees along with those planted. Where, however, a portion of the coppice must be left in a thick state to answer the purpose of cover, then the least promising part of the crop may be left—one stock here and there with all its shoots—so as to produce a sufficiency of cover without materially affecting the well-being of the general crop.

In training up a mixed coppice-and-timber plantation of this description, considerable attention is necessary to see that the coppice growths do not injure the young planted hardwoods. From the rapid growth of the former in the early stages of development, they are very apt to overtop the latter, which are of comparatively slow growth till they become well established and enter into the most vigorous period

of growth in height. But, in all other respects, the crop may be weeded, cleaned, and thinned just as in the case of other hardwood plantations.

Continental Method of Treating Copse or Stored Coppice.—As with everything else relating to forestry, coppice under standards is treated far more methodically by the French and Germans than in Britain.

At the end of each rotation of the **coppice or underwood**, young **stores or standels**, as they were formerly called in Britain, are selected, of seedling growth if possible, and are successively retained to form the **standards or overwood**, the oldest class of which is harvested along with the coppice at the termination of each period of rotation. The total extent to which the standards may be allowed to overshadow the area, or, in other words, the number of standels left at each time of felling, depends essentially on the amount of shade that can be borne by the underwood; and this, as is well known, is directly proportionate to the freshness and general quality of the soil, and to the shade-bearing capacity of the species of trees forming the undergrowth. It is only on the very best classes of woodland soil, and when the underwood consists entirely of species that bear shade well (like Beech and Hornbeam, or in a less degree Maple, Sycamore, and Chestnut), that the standards may be allowed to stand so thickly as nearly to overshadow the whole area. On poorer land, or when the underwood contains a large proportion, or sometimes merely a considerable sprinkling, of light-demanding species (like Oak, Ash, Elm, Willow, Poplar, Birch), the overshadowing of the standards just before the harvesting should not cover more than one-fourth of the area. But between these limits the conduct of operations must be left to the individual skill and knowledge of the forester.

It will be seen from the above that measures combining good returns from both standard trees and coppice underwood can only be reasonably anticipated from land that is above the average in quality, and that on any class of soil the standard trees should be as lightly foliaged as possible, whilst the underwood should be formed of the shade-bearing species most remunerative in the locality. These are the three fundamental factors which regulate the treatment of sylvicultural crops of this character: (1) quality of the soil, and in particular its freshness; (2) lightness of crown in the standards; (3) shade-bearing capacity, and consequent density of crop, in the underwood.

As the coronal development, and consequently the amount of shade cast over the soil, increases gradually with the age of the standards, it is found necessary to diminish the number of standards of each class at every time of harvesting the crop. Thus, for example, if the fall of wood in such crops is to take place once every twenty years, *i.e.*, if one-twentieth of the whole area under the crop is to be harvested annually, and if the oldest trees are to be felled at one hundred years of age, then the following will be the classes of growth on the area:—

Immediately before the fall.	Class of wood.	Immediately after the fall.
20 years of age	Underwood	0 years of age
40 "	Young stores or standels	20 "
60 "	Young standard trees	40 "
80 "	Standard trees	60 "
100 "	Old standards	80 "

If it be taken for granted that during each period of rotation the area overshadowed by each individual tree of these different classes becomes doubled—a matter that is, however, dependent on the species of tree and on the length of the period of rotation or number of years between each successive fall on any given area—then equal areas will be overshadowed at any time by—

1 old standard = 2 standard trees = 4 young standard trees = 8 young stores or standels.

Hence, if at the succession of the next time of rotation, *i.e.*, the next fall of timber on the given area, the same disposition of standards is desired as has hitherto obtained, this can conveniently be regulated by allowing the younger classes, from stores or standels up to standard trees, to remain on the ground in the given proportion. In this case the wood and timber harvested at each fall would remove all the underwood (except the seedlings left as stores), and all the old standards, twice as many standard trees, four times as many young standard trees, and eight times as many of the young stores or standels left over on the last occasion of felling. And in like manner, if more or less overwood be thought desirable, with due consideration to the productive capacity of the soil and the respective nature of the standards and of the underwood, then lighter or heavier clearances among the various classes of standards may easily be calculated, as seems most advantageous under consideration of all the concrete factors of soil, situation, species of tree, and local market prices, under the given circumstances of any particular case. Gayer (*op. cit.*, p. 159) gives the following critique of this method of treatment of timber-crops:—

"This system undoubtedly offers very great attractions to private owners of woodlands that are too small in area to be treated under purely high-forest crops, so as to yield regular returns every year. But such regularity of treatment as has above been sketched is hardly practicable over extensive areas, and for one of the very same reasons that has been adduced in support of the formation of mixed woods, viz., that changes in the quality and depth of soil will, in all properly managed woods, necessitate variations as to the species of underwood and the species and number of the standards. The leading principle has, however, been sketched in what has been above said, and the details can only be recommended after full investigation of the local circumstances and conditions in each concrete case. Thus, for example, if forty or sixty-year-old standards are more marketable and remunerative than older trees, then the management may be confined solely to their production along with the underwood; or if there be any specially favourable market for sturdy Larch of these ages, then good transplants may be put out here and there at the time of making the falls, for under such circumstances this tree finds specially favourable conditions for very rapid and exceptionally healthy growth.

"In many parts of Germany the principle of this method has been carried so far as to have coppice of two ages, which differs from the system of reserving standards only in so far as the stores or standels are usually only of coppice-growth, instead of being raised from seed, as is the case in the proper treatment of copse or stored coppice.

"For ship-crooks of Oak, or beautiful forked growth of Ash for furniture and the like, this form of timber-crop has special advantages. But although more conservative of the productivity of the soil than pure coppice treatment, it is distinctly less so than the system of producing timber in high-forest. And there can be no doubt that the general requirements of the future timber-market will be better met by the growth of long, straight,

clean stems in the close canopy of high-timber forest than under conditions in which ramification and coronal development are greatly stimulated by the undisputed possession of a large individual growing-space.

"Of the total quantity of wood produced, a much higher percentage falls into the less valuable class of branches and brushwood in copse than in high-forest; for, whilst this seldom amounts to more than 20 per cent. in the latter class of woods, it often rises to 40 or 50 per cent. of the total outturn from standards over coppice."

Formation and Tending of Osier-Holts.[1]—In most countries in Europe the Osier or Willow is much cultivated for the purpose of basket and crate-making, and as hoops for various sorts of barrels and boxes; whilst in the United States of America, in Canada, and even in Australia and New Zealand, this kind of crop is now being cultivated to a considerable extent for the same purposes.

In Great Britain alone there are estimated to be about 7,000 or 8,000 acres of land under Osiers, producing, on an average, about 3 tons of rods or withes per acre, or about 20,000 tons annually. In addition to this, large quantities are imported from the Continent every year. But there can be no doubt that the Osier crop of Great Britain might very profitably be largely increased, so as to be of far more importance in the economy of the country than at present. Tracts like the Fen districts of Lincolnshire and Cambridgeshire are particularly well suited for the extension of this industry.

With the present extension of fruit cultivation, the demand for Osier rods must steadily increase; and, if British landowners do not try to meet the demands of the market, trade of this description must more and more fall into the hands of the Belgians, French, and Germans, who already supply our markets to a very large extent, solely owing to our own negligence.

Many are of opinion that Osiers do not grow well unless they are planted on land having a moist subsoil. This is a mistake, however. Again, although the Willow prefers soil of a cool and moist nature, it will not thrive on land having stagnant water in the subsoil. Nor does it succeed well on land of a very dry description, as its roots do not there find sufficient moisture to maintain the balance of normal and healthy transpiration. The description of land most suitable for the healthy and full development of the Osier is a strong loam of an argillaceous rather than a sandy nature. Still, as land of this particular character is not available in all parts of the country where it may appear desirable to grow Willows, a light loam will also prove

[1] The attention of those who are specially interested in this method of utilising suitable land sylviculturally, is called to the pamphlet on *The Cultivation of Osiers* issued by the Board of Agriculture $\left(A\frac{3-93}{I}\right)$ during June 1893, and to a report on *The Cultivation of Osiers as a Means of Utilising Boggy Land*, contained in the *Transactions of the Highland and Agricultural Society of Scotland* for 1893, p. 180.

suitable, provided always that it be deep, and has a cool, moist subsoil, as is so often found to be the case in hollows and on low-lying tracts.

The land for Osier-holts should in all cases be thoroughly drained, in order to remove stagnant water from the subsoil, and then well trenched and cleaned to the depth of 20 to 30 in. before planting out the Osiers.

There is a very great variety of cultivated Willows. Some of them are noted for their fineness and toughness for basket-making, others for their quality of splitting for various purposes, and many for their strength of annual growth, which renders them most suitable for the making of crates and barrel-hoops. In every part of the country where Osiers are grown, the cultivator has some particular variety he prefers before all others, whether it may be for basket-making, for crates, or for hoops; hence reference need not here be made to any particular sort for recommendation, as the choice of species depends to a considerable extent on the object the planter has in view with regard to the sale of his crop.

As, in dealing with the Willows (vol. i. chap. ii. p. 172), only the Tree-Willows—the White Willow, Crack Willow, and Bedford Willow—have been described, the following extract from *British Forest Trees*, p. 327, may perhaps be of use for convenient reference :—

"Of the smaller varieties cultivated in osier-beds or 'holts,' the true Osier or basket-osier (*S. viminalis*) is the most important, being characterised by the toughness and flexibility of its thin withes or 'rods' as they are called in the Fen tracks of Eastern England, which grow in thick clusters; the Laurel Osier (*S. triandra*) yields a plentiful crop of long, flexible twigs; the Purple Osier (*S. purpurea*), so called from the colour of its anthers during the time of flowering, produces very thin but exceedingly tough withes, principally used for basket-making. So far as the various species can be determined by their leaves alone, the following short descriptions may be of use :—

"*S. viminalis.*—Leaves very long, with white, close-lying hairs having a silky gloss. Stipules small, temporary or fugacious, shorter than the petiole, or altogether wanting.

"*S. triandra.*—Leaves quite smooth, finely serrate.

"*S. purpurea.*—Leaves often opposite, smooth, bluish-green, lanceolate, finely serrate towards the apex, and becoming somewhat broader; without stipules."

Osier plants should always be reared from cuttings which are schooled in the nursery for one year previous to planting them out permanently; for by such treatment they are capable of producing a strong crop one year earlier than they would if the cuttings were planted on the land at once. The slips or cuttings should be taken from the strongest of the one-year growths of the variety to be cultivated; and these may be schooled in the nursery-lines at 3 in. apart, and with about 15 in. between the rows. The cuttings should be made about 12 in. long, and each inserted to about two-thirds of its

length into the ground; whilst, in making the slips, each should be smoothly rounded at the lower end with a sharp knife, and cut with a long slope on the upper end. Planted in this way, the cuttings will throw out numerous strong fibrous roots during the first season, and become so strong in the stem as to be fit for planting out permanently during the following spring.

When the object is to raise a crop of rods for basket-making, the Willows may be planted 12 in. apart in the rows, and with 24 in. between the lines. Where a stronger class of withes is wanted for crates and hoops, however, the plants should be put in about 18 in. apart in the rows, and with about 30 in. between the lines.

The Osier-holts should always be kept clear of weeds by hoeing the land frequently, as occasion may require, during the summer months. If this be not specially attended to, the yearly weight of the crop will not increase to the extent it is capable of doing under proper management with respect to cleaning.

The following is the method adopted in the Fen country (Board of Agriculture's pamphlet, p. 3):—

"Planting should be done in February or March. The sets are cut from wood of two years' growth—they should be 16 or 18 in. long, and about 10 in. of the set should be in the ground. During the spring and early summer the spaces between the rows must be kept clean by hoeing and forking. The cleaning must be completed before the middle of June, or the Osiers will be injured. The cost of cleaning is variously estimated at from £1 to £2 per acre per annum for the first two years. After that time the expense of cleaning is much less, as the dense and rapid growth of the Osier stifles and smothers all other vegetation. It may be mentioned in passing that the young shoots from an established stock will make a growth of 18 in. in the course of a single week."

In harvesting a crop of Willows from the stocks, the operator should be careful to cut close to the part from which the rods or withes have sprung. If this should not be well attended to, the stocks will rapidly enlarge, while the Willows will become proportionately smaller. The best cultivators of Willows generally make a point of cutting off from time to time, as may be found necessary, any overgrowths on the stocks, in order to keep them all of proper size, and in a healthy, vigorous, and productive condition.

The full annual growth of the rods is completed by September, when the shoots from well-established and vigorous stools will be 6 to 7 ft. in length, or even 8 to 9 ft., and occasionally much more, in the case of some species of Osiers.

After the holts have been cropped for the season, the ground should be regularly dug between the lines,—not deeply, but only in such a way as to kill any root-weeds growing on the land, and to improve the soil by aeration and exposure to the influence of the

weather. Where the land is not naturally fertile, it may be advisable, in order to ensure its producing a heavy crop of Willows for the market, to give it a good manuring of well-rotted dung once every three years. In the author's opinion, the cultivator of Osier-holts ought therefore to arrange to manure one-third of the area annually, so as to ensure that the whole extent would be manured once in every three years.

Where winter floods occur, as is frequently the case in the Fen country, the silt deposited is better than any artificial manure. Summer floods, during the period of active vegetation, are, however, injurious to the crops.

As soon as the rods or withes are cut from the stocks, they are at once carried off the ground, assorted into three sizes, and tied into bundles of a certain number each, in which state they are sold at so much per 100. Sales are also, however, often made by bulk in some parts of England. Whenever this is the case, after the Willows have been assorted into three sizes, each size is tied up into bundles of a certain circumference, generally 24 in. at 1 ft. from the lower ends, which are sold according to their length.

When it is wished to prevent Willows from drying and becoming brittle after they are cut from the stocks, they should have their lower ends inserted about 1 ft. into the soil in the bundled state; or the bundles may have their lower ends immersed in a pool of water.

Throughout the Fen country the harvesting of the rods commences in January if the holts are not inundated or too marshy. But the harvesting should take place at any rate before the sap begins to rise, in order to prevent "bleeding" of the stools, which prejudices the development of the following crop. If the rods are to be peeled, so as to increase their technical utility and their market value, they are placed with their butt-ends in water in the peeling-yard till the rise of the water makes the bark strip easily. And as regards the outlay required for the formation of Willow coppices (*idem*) :—

"The cost of preparing and planting an Osier-holt is variously estimated at from £14 to £23 an acre, the amount depending upon whether the land is trenched or ploughed, and upon the preparatory cleaning which may be necessary. Taking an outside estimate, the items of expenditure would be as follow :—

Fallowing	£4	0	0	an acre.
Trenching	8	0	0	"
Sets, 20,000 at 10s. per 1000	10	0	0	"
Planting	1	0	0	"
	£23	0	0	"

"This is without allowance for manure. On the other hand, if fallowing is not required, and ploughing is resorted to, the cost would not exceed £14 an acre."

In the Fen country the harvesting of newly-planted holts takes place at three years; but, in general, four or five years must elapse before the crop is mature.

An average crop will yield about 150 bunches of rods, having a girth of 45 in. (an English ell) at 1 ft. from the thick end of the bunch, whilst a heavy crop may reach 250 bunches; the weight of rods may vary thus from about five to ten tons per acre. The harvesting of the rods is paid for at about 2s. 6d. per score of bunches, or about 1½d. per bunch on the average. The selling price of these has of late years ranged from 1s. 6d. to 2s. 6d., and is at present about 2s. per bunch. If the green rods are peeled so as to command a better price and to store well, then there is a loss of fully 50 per cent. in bulk, as three bunches of green rods yield only two bunches of clean or peeled rods.

The monetary returns from Osier-holts in the Fen districts are at present about £15 an acre, taking 150 bunches of green rods as the average crop; this, of course, is subject to deduction of all the costs of planting, tending, harvesting, ground-rent, taxes, supervision, &c. The cost of peeling, sorting, and handling the same so as to transform the crop into clean white rods amounts to about 8d. per bunch, or £5 per acre. Thus in the above case a crop of 150 bunches of green rods would, when peeled, yield 100 bunches of white rods, having a market value of nearly £35. The cultivation of Osiers on suitable land seems well worthy of attention; for, as one of the Willow-growers of Fenland states (*idem*):—

"A holt planted in a suitable site, well planted, cleaned, and cared for, filled up and replanted when necessary, has always paid its way; and where the circumstances allow of peeling the rods, a very good result has been obtained."

The attention of these Osier-growers may, however, be drawn to the remarks made over-leaf on page 201, with regard to utilisation of the bark.

CHAPTER XI.

THE UTILISATION OF FOREST PRODUCE.

A.—Minor Forest Produce and Intermediate Returns.

I. **The Harvesting of Tanning-Bark.**[1]—The stripping and drying of bark used for tanning is sometimes an important part of British forestry; hence, unless thoroughly acquainted with the proper manner of performing this work, a forester may cause much loss to his employer through bad management.

Although there are various kinds of bark suitable for tanning purposes, yet at the present time there are only three kinds of trees the bark of which is utilised in Britain for tanning purposes, viz., Oak, Larch, and Birch. Other barks have been used for the purpose, such as Willow, Mountain-Ash, Spanish Chestnut, and even Alder; but now that large supplies of Oak-bark are imported into this country from the Continent, tanners do not use these, seeing they can get plenty of good Oak-bark at a moderate rate. And it is in consequence of this large supply from the Continent that the price of bark is now so low.

Particular attention will here be given to these three kinds of bark first mentioned. Even though the operations are in each case almost alike, still there are a few minor differences which it is necessary to refer to, in order that the stripping of each species may be properly performed.

The market for tanning bark has of late years become considerably depressed in England, owing not only to the increased imports of bark from the Continent, and of Oak-galls from the Mediterranean lands, but also to the ever-increasing imports of Cutch and Gambier from India, Divi-divi from

[1] The attention of the student may here be called to a report on the *Peeling and Harvesting of Native Barks* in the *Trans. Scot. Arbor. Socy.*, vol. ix., 1879, pp. 58–62, and vol. xii. part iii., 1890, pp. 433–447.

Brazil, &c. And there can be no doubt that if chemists prove successful in their search for a cheap substance to take the place of these more expensive materials, the market must sink below the level at which sylvicultural production of tanner's-bark could possibly prove remunerative.

The quantity of tannin in Oak-bark depends chiefly on the age of the crop and the nature of the soil and situation; it varies from 6 to 20 per cent. in the sorts thrown into the market. According to Gayer (*Forstbenutzung*, seventh edition, 1888, p. 390), bark from young Oak-hags in Southern Germany, Austria, and Hungary, contains 15 to 20 per cent. of tannin, middle quality 10 to 15 per cent., and old bark 8 to 10 per cent.; whereas in the colder climate of Northern Germany, the percentages vary from 6½ to 10, and that yielded by Spruce-bark is about 6 to 8. According to analyses made at the Moscow Academy, Osier-bark contains from 8 to 12 per cent. of tannin; it is the bark used in the preparation of "Russia leather," and of the "Danish kid" of glove-makers. It may also be used in the preparation of salicin, or for fodder, &c. The possibility of making any revenue out of the Willow-bark seems to be overlooked by the Osier-growers of the Fen districts; at any rate, no mention is made of such utilisation of the skins of peeled rods in the Board of Agriculture's pamphlet on *The Cultivation of Osiers*, 1893 (see vol. i. p. 44, and vol. ii. p. 195). The peculiar aroma of Russia leather is obtained by steeping it, after tanning with Willow-bark, in a preparation of Birch-oil, distilled from the white epidermis of Birch-bark.

Oak.—The best season for stripping the bark of the Oak is when the young leaves are just beginning to flush. Generally speaking, it will peel freely from the 1st of May to the end of June; but a great deal depends upon the part of the country in which the work is performed, and also upon the general nature of the season. In the south of England, barking operations may be commenced about the middle of April and completed by the middle of May; while in the central and northern parts of Scotland, a commencement is only made during the first week in May, and operations continue until the beginning of July. In Ireland, as a general rule, Oak-peeling may be performed from about the end of April to the middle of June.

A few words regarding the utilisation of Oak-bark in general seems opportune here, and these may conveniently be given in the form of a quotation from Burckhardt (*Säen und Pflanzen*, 1893, p. 38):—

"**Utilisation of Oak-Bark.**—The cultivation of the Oak in the forests of Northern Germany, and in most other German woods, is principally with a view to the production of timber, to which are subordinated the considerable advantages often gained in firewood, bark, and acorns, also in grazing and litter on pasture-lands. Throughout Northern Germany, Oak-coppices or hags for the production of tanning-bark occupy merely a minor position; whilst copse with Oak standards receives somewhat more consideration. But, on the other hand, throughout Western Germany, Belgium, France, and Holland, Oak-coppices are cultivated very extensively for tanning-bark. The vast Oak-coppices in the Odenwald, on the Neckar, in the valley of the Maine, and in the hilly tracts of the Central Rhine district, together with its

numerous great side-valleys, owe their favourable monetary returns principally to the utilisation of the bark; whereas the good, but usually small, wood yields only the minor portion of the revenue. Worked mostly with a rotation of 14 to 18 years, such Oak-hags yield excellent smooth bark on favourable classes of soil and situation, and thereby supply the raw material for a brisk trade, especially in the preparation of soling and glazed leathers. The bark is sometimes sold in the forest, and sometimes at special marts, according to samples, which latter method is finding imitation in other districts. Amongst the most celebrated of these bark-markets are Heilbronn, Hirschhorn, Bingen, and Alzey.

"That tanning-bark is most highly prized which is produced on rich mountain-soil, on sunny exposures, and in crops that are not too dense, and which is thick, fleshy, and still smooth and unfissured. When grown at high elevations, the bark of the sessile Oak is better, both as regards quality and quantity, than that of the pedunculate Oak."

From the differences in climate, and having regard to the natural climatic requirements of the Oak, it will be at once seen that though Oak-coppices may often prove a remunerative crop in Southern England, they are less frequently suited to forest-land in Scotland.

1. British Method of Stripping Oak-Bark.

(*a.*) **Coppice-Woods.**—Some time before commencing the cutting and stripping, the forester ought to mark all the trees or coppice-shoots that he intends to be removed, in order that he may have plenty of time to devote to the work of stripping when this is begun; because, if the plantation be extensive, and many hands are employed, he will find enough to do without marking when the people have begun to work.

He must next calculate the number of hands he will have to employ, in order to do the work within a given time.

Supposing, for example, that an Oak-coppice is to be operated upon, he should first take three shoots or trees of different sizes, one of an average small size, one of an average medium size, and one of an average large size. If the bark stripped from these three average specimens weighs 39 lb., this gives 13 lb. as an average of the raw bark which may be expected from each stem to be stripped. And supposing that there are 7,466 trees in all to be taken out, then, if it be assumed that the raw bark in drying loses over one-third of its weight, only about 8¼ lb. instead of 13 lb. must be calculated as the weight of dry bark yielded by each tree; hence the total yield would be about 61,594 lb., or fully 27 tons. From the above method of calculation the forester may generally arrive at within about 5 per cent. of the actual out-turn.

Having ascertained that 27 tons of bark are likely to be yielded by the plantation, the next point is to calculate the number of hands required to complete the work, say, in 27 days. In order to strip one ton of bark each day, including all the necessary operations pertaining thereto, the following working-staff will be required:—

1 lad, stripping lower parts of stems, at 1s. 6d. per day . .	£0	1	6
1 man "laying in" these, at 3s. per day	0	3	0
2 cutters, at 3s. per day	0	6	0
2 pruners of trees, at 2s. 6d. per day	0	5	0
3 lads pruning branches, at 1s. 6d. per day	0	4	6
2 boys carrying branches, at 1s. per day.	0	2	0
1 man putting up stages, and attending to bark on them, at 2s. 6d. per day	0	2	6
2 lads carrying bark to stages, at 1s. 6d. per day	0	3	0
12 women or boys stripping, at 1s. 6d. per day	0	18	0
	£2	5	6

Before the trees are cut down, a boy proceeds to strip off the bark, to the height of about 3 ft. from the ground, right round the stem of each tree. This is done in order to prevent any waste of bark when the trees are being cut down, and to allow the cutters to apply their axes and saws the more readily. If it be intended that the stools of the trees to be cut are to be treated as coppice, then the boy should have instructions to be careful not to tear away any of the bark from the bottom of the tree, or from that part which is to be left as the stock after the tree is cut. In order to keep the stump uninjured, the boy should first notch the bark through to the wood, all round the tree, with a light hatchet or handbill, about an inch or so above the surface of the ground, and also about 3 ft. from the ground. He will next strip off the piece of bark with the barking-iron (Fig. 261), in the same way as is done by the regular strippers, and should endeavour to take it off in as large pieces as possible, in order to have the bark taken from the butt of the tree as a covering for the smaller bark on the ranges. In this way he should proceed from tree to tree before the cutters, stripping the lower part of each stem in a similar manner.

If the stems are to be felled with the cross-cut saw, as is advisable when they are over 6 in. in diameter, a man should next follow with an axe, and "*lay in*" the outspreading lower parts of the stems of the trees, in order to prepare them for the saw. This should be done in a neat workmanlike manner, and in such a way as not to injure the stocks.

After the men have cut down the tree with the saw, other two men should follow with hatchets, and prune the branches from it; and in doing this they should be careful to cut off the branches in such a way as not to destroy the bark upon the main stem of the tree. The hatchets used for this work should be of a lighter description than those used by the cutters, and should be broader on their face.

These men are followed by three strong lads with handbills, of

the description shown in Fig. 259, which are kept sharp both on the curved side *a*, and upon the straight face *b*. With these handbills the branches are cleared of all twigs, and cut up into lengths of about 4 ft. All branches should be thus dealt with, even down to those of about 1 in. in diameter at the small end. As they are pruned out and cut into lengths, they should be thrown regularly into heaps by themselves, so that they may be readily lifted and carried out of the wood by the next party. Of course, when large trees are cut down, many of the branches will be much too large to be cut in this manner by the lads. These can be left uncut, to be stripped by those who are taking the bark off the trunks of the trees in the usual way. It should be the care of the forester to see that these lads do not pass over any of the branches, as they are very apt to do, in order to keep up with the men in front; for, by thus passing over some of the branches, a considerable quantity of bark may be lost.

Fig. 259.

Other two boys now take the branches that have been put in bundles, and carry them out to the nearest road in the wood, or other convenient place, in order to be stripped of their bark as described later on.

After the trees have been cut down and pruned of their branches, a few of the workpeople should begin to strip them of their bark. The tools required are a mallet, a handbill, and a stripping-chisel or peeling-iron, and also, if the trees are small, a pair of forked stakes. The head of the **mallet** (Fig. 260) should be made of good Ash, 4 in. square at the flat part *a*, and about 6 in. deep to the sharp part at *b*;

Fig. 260.

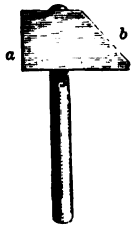


Fig. 261.

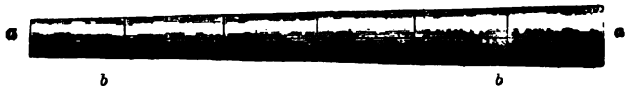
Fig. 262.

while the handle may be of Pine, as it is softer and cooler for the hand than any other kind of wood, and should be 10 in. in length. These mallets are used for beating the bark upon the wood when it does not come off easily with the peeling-iron. They should only be used when the bark cannot be got off otherwise. The **stripping-chisel** or **peeling-iron** (Fig. 261) should be made of good iron, about

2½ in. on the face *a;* the hose *b* should be about 4 in. in length, while the handle *c*, which is of wood, may be about 8 in. long. One side of the iron should be a little curved, so as the more readily to go round the tree in taking off the bark.

In stripping the trees, it is usual for two people to work at each stem, so as to assist each other. As already mentioned, if the trees are not too heavy, two forked stakes, like those used in putting up the stages, may be erected to receive the end of the stem. These are placed in the ground in a slanting position opposite to each other (Fig. 262), and the end of the tree is lifted and put upon them. When the stem is thus raised, one of the peelers takes a handbill (Fig. 259) and cuts the bark right round the tree into lengths of about 30 in., beginning at the thick end. With the same implement, he then cuts it longitudinally from the one end to the other—the bark being thus divided as shown in Fig. 263, *b*, *b* representing the transverse cuts, and *a*, *a* the longitudinal cut. While the one man is thus engaged, the other beats the surface of the bark all round the tree with the flat end of his mallet, if the bark will not come off readily with the peeling-iron. In many parts of England, where the

Fig. 263.



bark generally comes off the trees readily, no beating is required at all; but in Scotland this method of loosening has usually to be practised to some extent. If the sap is well up in a tree, very little use need be made of the mallet; and it will be found that some trees are very readily stripped, while others close to them will be very difficult to peel. If beating *must* take place, it should be done very softly and slightly, and on no account in a rough or heavy manner, as this would injure the colour and quality of the bark when dried. The thinner the bark is, the less beating will be required; while thick strong bark is generally more difficult to come off. All this the people who are employed should be made aware of, as the better knowledge they have of the real nature of the work, the more profitable they are as workmen. As soon as the bark has been cut into lengths, one man will take his stripping-chisel and separate the bark from the wood, taking it off in pieces corresponding to the cuts he made with the bill; and as he takes off each piece, he will lay it aside in a heap with the other bark on the same tree. In this way one workman will follow the other in close succession; and as soon as one stem is stripped of its bark, they will throw it off the forked stakes and proceed to another. When the stems are too large and

heavy to put upon the forked stakes, the men should first remove the bark from the upper side, and then get the stem turned over, so as to remove the remainder.

Whilst the men are thus engaged with the stems, the other hands will require to be stripping the branches, that were cut into lengths and carried out to the road. Each woman or boy should have a separate heap of branches to strip, as then the work is generally done better and more quickly. Each should be provided with a flat smooth stone, from 8 to 10 in. square on the top, and about 6 in. deep, in front of which the stripper will sit down upon the ground, keeping the bundle of small wood to be stripped upon his or her left side, and placing the stone upon the ground close to the left side also, with the smoother side uppermost. He or she takes a branch in the left hand, then lays it upon the stone, and beats the branch firmly with the flat part of the mallet, till the bark opens from the wood, moving it along from one end to the other, and applying the mallet at the same time. After the branch has been thus beaten from end to end, the bark will come off easily with the hand; or, if it should still stick to the wood, the chisel can be applied to take it off. In peeling off the bark from the branches, it should be kept in as long lengths as possible, and laid in a bundle by itself beside the operator, who will in this manner strip all the branches in his or her heap.

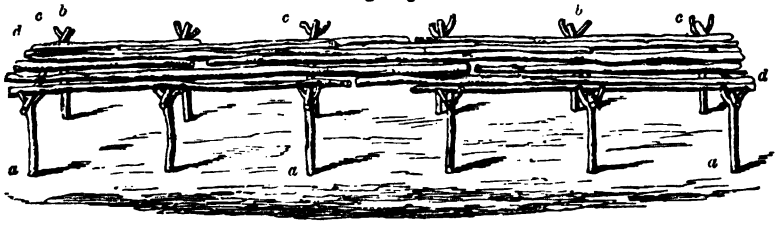
As the bark is taken off and laid aside in heaps, it should be carried away by two lads, whose duty it is to take it to the man putting up the stages and attending to the drying of the bark on them. The bark from the branches can be carried to the drying-stages at any time when a sufficient quantity is taken off, say in the middle of the day, or in the evening before closing work.

The duty of putting up the stages, and of attending to the proper drying of the bark, should always be intrusted to a careful man who has had some experience in the work. In fact, this is perhaps the most important point in connection with the stripping and drying of any kind of bark; and in wet or showery weather it is often a difficult matter to get bark properly dried at all. The drying-stages should be erected on some open and airy part of the plantation, or outside it, where a free circulation of air may be continually had, and where sunshine may fall upon the stages as long as possible. On the drying depends the harvesting of the bark in good condition; and if the stages are put up in a damp and sheltered situation, or under the drip of trees, the result will be that the bark will take a long time to dry, if it ever does become properly seasoned. This will cause almost double the expense in curing that is incurred with proper attention. For the erection of the drying-stages, a number of forked stakes, as in Fig. 264, of from 2½ to 3 in. in diameter, and

about 3½ ft. long, should be collected from the stripped sticks, and should be driven into the ground in pairs opposite to each other, so as to form a double row about 2 ft. broad. Fig. 265 gives a general view of the complete stage, *a a a* representing a front view of the forked stakes as they are driven into the ground, and *c c c* the tops of the row behind and opposite to them, whilst *b b b* represent pieces of the stripped sticks resting between each pair in their forked tops, and *d d* small poles of about 2 or 3 in. diameter, laid along on them for the purpose of supporting the bark. The distance between these forked stakes, when driven into the ground, may be about 4 ft. in the row; and in order that the rain may fall readily off the bark on the stage, the front row should be driven in with their tops about 4 in. lower than the back row. As soon as the bark is brought from the strippers by the lads, the man should place it upon the stages. In doing this he should take great care to put it on regularly, and lying all one way, like drawn straw. The whole bark, beginning with that stripped from the branches, should be put on loosely, and not pressed together, but kept open, in order to allow the air to pass freely through it. The bark should never be

Fig. 264.

Fig. 265.



laid on thicker than about 6 in., and should always be placed with the inner or white side downwards; while on the top of the whole, as it is finished, the larger pieces, taken from the trunks of the trees, should be laid on with the rough outside uppermost, in order to keep off rain from the bark lying below.

When the bark has stood for a few days upon the stages, it ought to be turned; all the freshest or greenest pieces should be kept at the top, mixing all the bark properly, but always taking care to keep the outside of the bark uppermost, and to have the larger pieces on the top. If the inner side of the bark be turned up, the action of the sunshine decreases the weight of the material, and also detracts greatly from its most valuable tanning properties.

If the weather continue fine, the bark may be seasoned in the course of eight or ten days from the time of stripping. But if it is dull and cloudy, two weeks may not be enough; and wet weather

may at any time retard the process of drying. No time can be specified, as this depends altogether upon the state of the weather and upon the situation of the drying-stages. The seasoning is facilitated by repeated turning during fine weather, and great care should be taken to see that the bark does not become mouldy or damped in any way. In wet weather it ought not to be touched, but the first fine day should be utilised for turning the bark. The proper stage of seasoning may easily be known by all the natural sap being out of the bark, and by this being so hard as to break instead of bending. When properly cured it should be of a cream colour inside. When of a dark brown colour, this shows that the bark has been injured by damp; and when this is the case, its market price will be lower. The more quickly it is cured, the better are its tanning qualities.

If there be the prospect of wet weather at the time when there is a large quantity of bark to be stripped in one district, a good plan is to erect a temporary shed on an open and airy part of it, in which to dry the bark. This shed may be erected on stout posts fixed in the ground at about 6 ft. apart in the line of one of its sides, and may be made of any height, length, or breadth, according to the quantity of bark to be cured. The sides should be left open, to admit the air freely; but the shed should be covered on the top with deals, which should be overlapped and nailed on, so as to prevent rain from getting through, or wind from displacing the roof while the work is in operation. The roof should also be made to project about 12 in. over the line of the side-posts, in order to throw the rain well out from the sides. In this open-sided shed stages of 3, 4, or 5 tiers in depth should be erected, on which the bark is laid to dry; and these stages may be made with rough wood to such a number as may be found requisite for the curing of the quantity of bark on hand. In a shed of this kind, however, the bark dries slowly as compared with that dried in the open; but the great advantage gained is that it is not exposed to wet. In order to dry it as quickly as possible, stages should be erected outside all round the shed, on which the bark may be laid during good weather, and whence it can be removed again to the stages inside when there is any appearance of rain. In this way any quantity of bark may be cured, even although the weather should prove wet occasionally. Every advantage should, however, be taken of any opportunity of putting the bark outside; and on no account should it be kept in a shed, unless the weather is such that it cannot well be cured otherwise. When drying in a shed, care should be taken that the bark does not get mouldy, as is very apt to occur if it be kept in a close confined place. Frequent turning is the only remedy against this; and all mouldy pieces should either be cleaned or thrown away altogether.

When thoroughly dry, the bark can either be sold to the tanners at once as it lies on the stages, or may be put in a stack, and kept thus until it can be disposed of to advantage. It is sometimes sold unchopped, but is more often delivered to the purchaser in bags, after having been chopped into small pieces. Supposing, for example, that the quantity of bark under notice has to be stacked, and afterwards sent away in bags, then the stack or rick should be built in an open airy place, where it will be exposed to drying winds, and where it will get plenty of sunshine. A good foundation should be formed by cutting and laying down pieces of wood of the required breadth, and then placing others of a suitable length crosswise over the former. In this way a foundation can be made, which will at once keep the stack off the ground and allow a free current of air to pass through below it. The poles need not be thicker than 6 in. each, or just sufficient to keep the bark at the bottom of the stack about a foot from the ground; while any openings there may be in the framework thus made can be filled up by placing a few of the stripped branches across them to prevent the bark falling through. In forming the rick, it ought not to be made wider than 7 or 8 ft. at the bottom, but may be of any length to suit the requirements. When making the foundation, it is a good plan to erect a few upright poles along both ends of the stack, for the purpose of guiding the builders and keeping the stack steady. These should be put into the ground about 2 ft., and each should have a stay, in order to prevent them from giving way with the weight that will be upon them while the stack is being built. As the work of building up the stack goes on, the centre should be well filled in with small bark, so that the middle of the rick may always be higher than the sides, and thus cause the side pieces of bark to slope downwards to the outside of the rick. The object of this is to prevent any rain-water from getting into the heart of the rick, which it would be certain to do were the outside pieces of bark either level or sloped inwards. The height of the stack may be in proportion to the breadth, but should not be more than about 8 ft. from the ground to the eave. The eaves should be made to project over the sides sufficiently to throw off the rain; whilst the top of the stack above the eaves should be made as steep as possible, and thatched with the largest flat pieces of bark that can be had. Other kinds of thatch are sometimes used, such as branches of trees, ferns, and broom; but when the largest pieces of the bark are properly laid on, much in the same manner as the slates on a house-top, they make the best thatch, as they admit a free current of air, although they keep out the rain.

If the forester has to deliver the bark direct to the tanner, it will require to be chipped and sent off in bags. In chipping bark

it is merely cut into small pieces of about 3 in. sq., and these are filled into large bags for the purpose. Each bag as it is filled is weighed, as the bark is sold by the ton to the purchaser.

(*b.*) **Timber-Trees.**—It is still the practice in some parts of the country to strip the bark from Oak-trees while they are standing. The chief reason for performing the work in this manner is either that trees thus dealt with are generally in hedgerows, or in close proximity to a field of corn, which would be damaged if the trees were cut down and laid among the crop,—or that the timber-merchant considers that the timber is of better quality when cut in autumn than it would be if cut at the time of stripping when the sap is rising. The work is performed by a man with a ladder. Beginning at the top of the tree, he strips off the bark with a barking-iron as he comes down. He also carries a small axe, with which he cuts off the branches as he descends, and these are stripped on the ground. The branches and bark are taken away at the time, while the trees are left standing to be cut in the autumn or winter months. This practice is now dying out to a great extent, and is giving way to the more common method of stripping the trees after they have been cut down.

2. **The Continental Method of Stripping Oak-Bark.**

(*a.*) **Coppice-Woods.**—The smooth-skinned and more valuable assortments of bark are only obtainable from younger woods under about twenty-five years of age at most; but in all localities where Oak-coppice forms the main crop, the period of rotation ranges from fourteen to twenty years, and it is only when a specially favourable market exists for the young poles that this is increased to twenty-five or thirty years. Where the soil and situation are favourable to the Oak, the coppices should consist purely of this species; for, as Gayer remarks (*op. cit.*, p. 393):—

"From the rational standpoint as to bark-production, it must be the rule *to endeavour to have a pure crop of Oak-coppice so far as possible* on all tracts on which the Oak can thrive; for the nett return from coppice-woods rises and falls with the less or greater admixture of other species. Neubrand is quite right in asserting that on good soil a mixed bark-coppice is a sign of negligent management."

And with regard to the number of stools per acre, of which the crop should consist, he says:—

"We consider a crop of 1600 to 1800 vigorous stools per acre to be the most suitable density under average circumstances, and under the supposition that thinnings are to be rationally conducted. In the formation of new Oak-coppices one should at any rate not exceed a distance of 5 ft. by 5 ft. in planting out."

The cleanings are begun when about two-thirds of the period of rotation have passed by. They have for their object the removal of all the other species of trees as well as the less vigorous shoots of the Oak itself. Owing to the enhanced supplies of light and of growing-space thus obtainable by the more vigorous shoots, they rapidly develop during the remaining five or six years of their growth into thick-barked small poles having a large proportion of the cambial layer, which contains the tannin and other reserve supplies,

and a relatively small proportion of the dry, corticeous epidermis; for on the general vigour of growth of the shoots depends the quantity of reserves stored up, and consequently the amount of tannin.

Wherever, as is usually the case practically, there are patches of other species which could not be removed during the cleaning without causing blanks in the crop, these are cut out during the winter or early spring before the harvesting of the Oak-bark begins. And at the same time in many districts the Oak-shoots are trimmed by the removal of all the little side-twigs as far up as a man can reach with a bill; whilst any young seedling stores or standels that the forester may wish to reserve to grow into timber-trees should also be marked. This latter procedure is, however, a measure distinctly at variance with the proper treatment of Oak-coppice, as it is the first step towards the formation of copse, and as the highest returns from bark-coppice can only be obtained when the crop has the full benefit of exposure to light and warmth.

The actual work of barking is proceeded with from May till about the middle of July; but the most advantageous time for peeling is *immediately after the opening of the buds*, which may be from about the end of April to the middle of May, according to the concrete climatic factors in any given locality. And in addition to the bark coming away from the wood most easily at that particular time, other important points are attained by accomplishing the work within that fortnight if possible; for (1.) the tannin and other reserve supplies begin to be more utilised in other portions of the organism after the vegetative activity re-awakens, so that there is a less percentage of tannin in the summer bark; and (2.) by an early fall, leading to an earlier flush of new coppice-shoots, the latter have better opportunities of hardening and seasoning thoroughly before any danger to them arises in the shape of early frosts in autumn.

Throughout Germany the principal method of peeling the bark is from the felled stem. The fall takes place with the axe, and is made as low down and as smooth as possible; and only such number of stems is felled at any time as may be completely stripped within one hour, so that one feller can keep two strippers busily employed. The bark only peels freely when stripped immediately after the fall; and poles that have lain on the ground for twenty-four hours require to be beaten all over with the mallet before the bark will come away—a measure that not only involves the expenditure of more time, but also depreciates the market-value of the bark harvested. For the beating is always a forcible proceeding; it must involve a certain loss of tannin from the cambial layers, which has been assessed at 20 per cent. (Gayer, *op. cit.*, p. 398.)

The instruments used are of a very simple description. They consist of the **small axe** (Fig. 266 *a*) and the **curved bill** (Fig. *b*) for the felling of larger and smaller poles,[1] and of the **barking-spoon** (Figs. *c* and *d*), a curved piece of wood or bone, about 8 to 12 in. in length, and flattened at the end. If made of bone, it requires to be fitted to a wooden handle, in order to have it of sufficient length to afford a good purchase. Barking-spoons of wood or bone are much preferable to those having iron points, as the latter discolour the bark and affect its appearance, if not also its ultimate quality slightly. Different forms of the barking-spoon (as shown in Figs. *c* and *d*) are preferred in different districts.

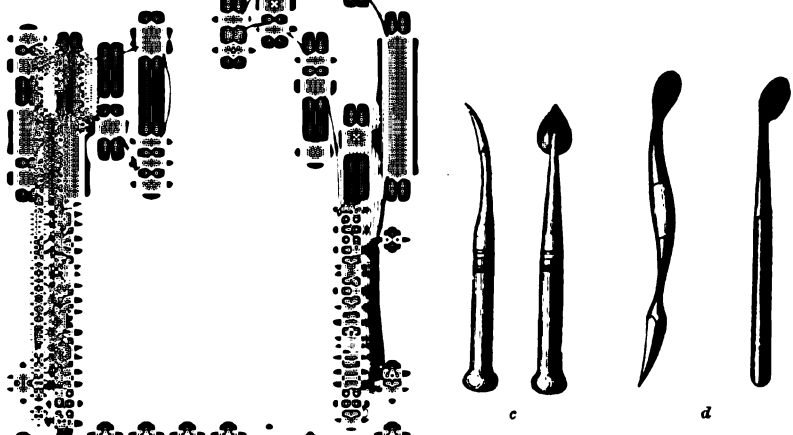
The method of peeling the stem when bent is largely practised in the

[1] The editor can very strongly recommend for such a purpose the heavy Burmese "Da," or bill, previously referred to on p. 185.

represented in Fig. 267; the pole *b* t through and bent over, and then se to the ground and barked also. reat advantages that the use of the rective, and that the bark is stripped f sap becoming interfered with by

tanding poles is especially practised in

266.



istria. The poles are first freed from nd then by means of the curved bill), strips of bark about $1\frac{1}{2}$ to 2 in. ight as convenient, which are bound poles to dry. The upper portion of part of the crop, is then stripped by being usually employed in order to

267.

d from the pole, but remains hanging d also prevents the use of the mallet, mall branchlets, which are very rich in

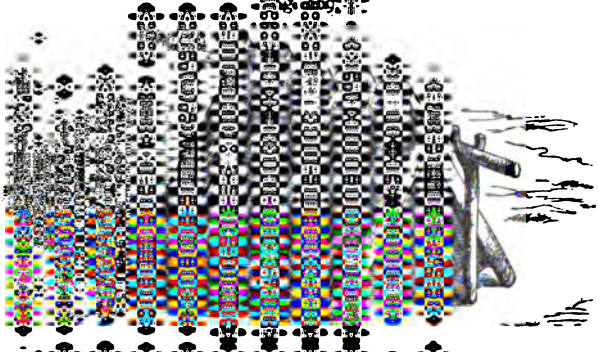
bark without the use of the mallet, a d (*idem*, p. 399), peel $2\frac{1}{4}$ to 4 cwt. in mallet is necessary, he can only harvest

of course kept in view
ee exposure to dry air,
p. The usual methods

and 269, which require
), the following changes

Smooth tree-bark.	Fissured tree-bark.
Per cent.	Per cent.
42	32
34	21

with the age of the crop,
value. If stacked for a
asoning in the open, the



in volume from 11 to 20
arkets immediately after
into bundles measuring

about 40 in. long and the same in girth, and weighing about 33 lbs. on the average.

(*b.*) **Timber-Trees.**—As in the case of coppice-woods, here also the stripping of the bark takes place in early spring; but it should be pointed out that this method is open to grave objections, which should deserve all the more consideration now that prices for bark are low. For, in the first place, if the Oaks be felled at the time of the sap rising, the technical quality of the timber is below what it would be with autumn or winter felling; and, in the second place, if there be any young growth underneath the standard trees, it is more apt to be injured than if the fall take place during the leafless time of the year. In the large tracts of copse with Oak standards in the neighbourhood of Hildesheim, the trees are barked in spring and felled in the following winter; whilst in other districts they are felled in January or February, and then peeled in spring. In the former case there is a loss of one year's growth of wood, and in the latter a loss in the quality of the bark owing to the use of the mallet; but in either case the damage to young growth is less than if the trees were felled during the time of the flushing of the leaves in spring.

As a rule, the barking operations take place after the stems have been felled, and only such number of trees should be cut as may be barked on the same day. The instrument used is a strong **barking-iron** (Fig. 270), with which a long slit is made in the bark, right down to the wood, at the butt end of the stem, and continued as far up as possible. It is then measured off in sections of one metre in length, and each of these is in turn peeled by

Fig. 270.

means of the iron and the hands, very much in the manner previously described in connection with Fig. 263. The use of the mallet in this case is unavoidable to a greater or less extent. When the stems are peeled standing, ladders have to be used; but as the bark strips more easily at the most favourable time of the sap rising, the use of the mallet is here unnecessary. In Germany a well-trained woodman can bark four to five large Oaks in one day if the weather be favourable (*idem*, p. 406). When the bark is rough and fissured, some cleaning is necessary, and this can most advantageously be done before the peeling operations are commenced.

The loss of material when coppice-falls are stripped of their bark varies from about 17 to 30 per cent.; but this is fully balanced by the better quality of the wood, even when sold merely as fuel. Hence, even if the market for tan-bark is not particularly remunerative, it will usually pay to bark Oak-coppices if there be any favourable outlet for firewood in the neighbourhood. Gayer (*op. cit.*, p. 347) gives 10 to 15 per cent. as the proportion of bark on mature coniferous timber.

Larch.—Larch is not now so frequently stripped of its bark as it used to be, as, from the large importations of foreign Oak-bark into the country, there is very little demand for material of this kind. It does not possess tanning properties in such high degree as the Oak; and for this reason it neither meets with so ready a demand, nor brings in so good a price. Frequent objections are raised by wood-

merchants, that if the Larch be left for any length of time after being peeled, it cracks and splits, especially if the weather happen to be hot and dry at the time. As this is sometimes a matter of importance, it raises the question whether it is not better to leave Larch without being stripped at all. The principal advantage gained by removing the bark from the Larch is the great saving effected in carriage. Larch trees, cut down and sold for pitwood, after being peeled lose about one-third of their weight; hence, where the wood-merchant has railway-carriage to pay, a considerable saving is effected in the freightage of the timber. The price obtained for the bark will generally pay all expenses of felling the trees and of stripping and curing the bark; so that the saving in the carriage is all a gain to the purchaser of the timber.

Michie (*The Larch*, 1885, p. 111) even says that—

"Larch, in the form of thinnings, and below thirty years old, should be peeled for the sake of the bark: the operation usually pays from 15 to 25 per cent., minus the cutting down and pruning."

Larch may be stripped from about the middle or end of April till late in the season; but the best time for peeling is when the young leaves are expanding from the bud. The actual operations are in all respects similar to those practised in the stripping of the Oak, with the sole exception that no Larch bark is taken from the branches of the trees, but merely from the stem. The mallet is seldom found necessary, as, when the bark on the tree is cut into lengths, it comes off easily with the stripping-chisel. In barking the Larch, fewer hands will be required to strip one ton per day than are required for Oak. The following is an estimate for cutting, stripping, and curing one ton of Larch-bark:—

2 cutters, at 3s. per day	£0	6	0
1 lad, putting up stages, &c., at 2s. 6d. per day . . .	0	2	6
2 lads, carrying bark to stages, at 1s. 6d. per day . . .	0	3	0
6 women or boys stripping, at 1s. 6d. per day . . .	0	9	0
	£1	0	6

The bark may be dried upon stages, or more easily by placing the lightest of the Larch-trees upon the ground, or upon forked stakes, and putting the bark on them. Larch-bark usually dries in a shorter time than Oak-bark, and is much less liable to injury, although due care must be exercised to prevent damage from mildew. In very favourable seasons it may even be stacked in four days after being stripped.

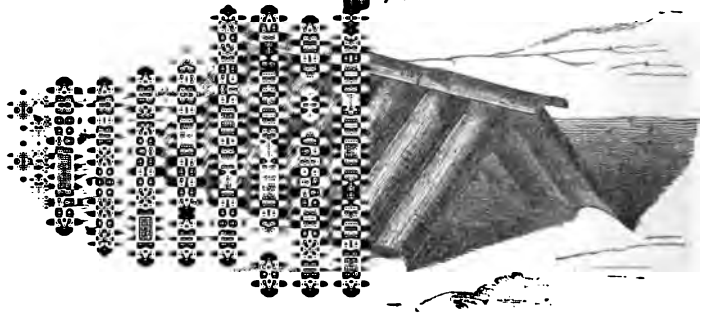
Instead of being chipped into small pieces with an edged tool, this kind of bark is very often threshed with flails. In doing this, a tarpaulin or waterproof sheet is laid out on the ground, and on it the

[illegible] The bark being dry and brittle, [illegible] be filled into bags as the work of [illegible] be done readily in this way, and [illegible] man per day.

[illegible] tensively practised in Austria, Hun- [illegible] of high enough quality for the prepa- [illegible] nt for calf-skins. Investigations have [illegible] d contained in Larch-bark is greater [illegible] *it.*, p. 409); hence stripping operations [illegible] e of the summer flush of foliage.

[illegible] ally throughout Eastern and Southern [illegible] -bark is harvested to a much greater [illegible] strong in tanning properties as Oak- [illegible] the preparatory stages of tanning or [illegible] takes place in much the same way [illegible] nd is usually carried out during the

[illegible] 271.



[illegible] ed in sections by means of the barking- [illegible] ing ranged in the roof-shaped fashion

[illegible] advisable in order to diminish the [illegible] with bark-beetles (*Bostrichini*), if the [illegible] of time before being removed from the

[illegible] 51), in Scotland a Larch tree contain- [illegible] ones (224 lb.) of green bark, equal to [illegible] tems yield 8 to 10 lb. of bark for every [illegible] bark for every load of 50 cubic feet of [illegible] ars old may be calculated to yield 7 to [illegible] imber. In the Highlands of Scotland [illegible] begin to strip easily about the begin- [illegible] a fortnight later in peeling readily. [illegible] d chipping and bagging other 7s. per [illegible] bout 15 per cent. of tannin, or rather [illegible] the best Oak-bark. The demand for [illegible] Scotland; but owing to competition, [illegible] btain than was formerly the case, and [illegible] best price obtainable for dressed bark

Under such conditions of the market, it becomes questionable if the barking of any large stems is really profitable. All large logs peeled in spring are apt to shrink and crack deeply during the summer; and this prejudices their market value for conversion into beams and scantlings.

Birch.—As is the case with the Larch, so also there is now comparatively little demand for Birch-bark. In some places it is still used for tanning, although not nearly to such an extent as formerly.

Birch may be stripped nearly a month earlier than Oak; but the best season for the operation is when the buds are beginning to burst.

In the stripping of Birch-bark the same process is gone through as with the Oak. It is much more easily dried than Oak-bark, being generally put upon a few sticks on the ground. Unless it has to be sent a long distance to the tanyard, this bark is generally sent direct from the stages unchipped; but, if necessary, it can be stacked, and afterwards chipped and bagged, in the same way as Oak-bark. As the bark is of small value, however, it will be found necessary to expend as little time and labour upon it as is consistent with its proper drying and harvesting.

Like Alder-bark, the bark of the Birch contains far less tannin than Oak, and considerably less than Spruce. Although the Birch flushes its foliage earlier than the Oak, Continental experience shows that barking operations are easiest about fourteen days after the Oak-bark strips most readily.

General Remarks on Barking Operations.—The first opportunity of the season should be taken advantage of to begin the work of stripping, for bark peeled late in the season is never so valuable as that harvested early. The work ought to be commenced as soon as the trees will strip; and if it should be found that some of them do not strip so freely as others, these may be left until later, when the plantation can be gone over again. Another advantage derived from an early start is that when the stools are intended to bear coppice growths, these come up with far more vigour than they would otherwise attain if the trees were cut later in the season.

If wood be allowed to lie more than one day unstripped after being cut, it will not peel so easily as when fresh. The forester should therefore be careful not to allow one party to fall behind another, so as to keep the wood lying for any time unstripped. The more healthy any stem is, the more easily and the earlier in the season will the bark peel; for an unhealthy tree never parts with its bark readily. Much of the success, therefore, in stripping wood will depend upon the general health of the crop.

It often happens that there is a mossy growth on the trees that are to be stripped; this should be scraped off the stems before they are cut down, and they should be pruned of their branches before they

are stripped. The proper tool for this purpose, the scraper, consists of a piece of iron about 6 in. broad in the face, which is semicircular, in order the more readily to fit the trunk of the tree. A handle of about 2 ft. in length is fitted to this, and is fixed at right angles to the iron. By moving the scraper up and down the stem, the moss can be easily removed; if this be not done, the bark will retain the moisture for a considerable time, and will be found difficult to dry properly.

Any unnecessary beating with the mallet is exceedingly objectionable. Some woodmen use the mallet far too much, thus rendering the bark easily spoiled by damp, discoloured, and inferior both as regards quality and market value.

In spreading the bark on the ranges, it should never be put on thickly, as if much be piled up in a heap it will take a long time to dry. If spread thinly on the stage and well attended to in the way of frequent turning and mixing, it will speedily be cured if the weather is at all favourable.

When a stack of bark is being built, or when it is being chipped, the forester should provide strong waterproof covers, similar to those used for covering railway trucks. These should be thrown over the stack or the chipped bark when rain threatens; for, if the broken stack or the chipped bark get wet, a great deal of trouble will be the result, and probably the loss of a quantity of the bark.

With regard to whether bark-stripping should be performed by piece-work or by day-wages, it is difficult to give any general advice. Where good supervision can be given, piece-work will stimulate the woodmen to work as fast as possible; but, at the same time, it will also tempt them to a free use of the mallet, and this affects the quality and value of the bark. On the other hand, day-labourers have not the same pecuniary motive for pushing on with the work, and therefore require a greater amount of supervision to see that they do not trifle.

Throughout Germany the usual method is to employ the men, women, and boys on daily labour under good supervision.

The larger that trees are when stripped, the greater is the quantity of bark that can be taken from them in a given time, and the cheaper is it stripped per ton. Thus Oak timber-trees may be cut down and stripped at the rate of 28s. per ton for the out-turn in bark; while, on the other hand, in cutting and stripping young coppice-shoots, as high as 60s. per ton may have to be paid for the work before the bark is dried and ready for sale. But the costs, of course, vary according to the rate of wages in the district, and the size of the stems that are stripped. Contract prices likewise vary in the same way; but from 30s. to 40s. per ton may be taken as

the general rate for piece-work. For chipping and bagging the bark about 6s. to 8s. per ton are usually payable. These rates refer only to Oak-bark, as Larch, Spruce, and Birch can be stripped and chipped and bagged for about one-third less.

The selling price of the different kinds of barks varies from year to year, according to the demand and to the season. Oak-bark generally fetches from £4 to £7 per ton, whilst Larch and Birch bring from about £2 10s. to £4 per ton.

Utilisation of Thinnings.—The stems felled during thinnings, whether they be large or small, young or old, should be at once removed to the nearest road, and arranged there, according to their kinds and sizes, for sale, or other method of disposal. The work of removal may either be done by boys or men, or horses may be employed to drag them out if this seems more economical.

The work may be given out by contract, provided always that good supervision can be relied on; but by contract there is great danger of careless performance, and very often the standing crop is more or less damaged.

In coniferous crops, wounds caused by the bumping of logs against the stems when being dragged out are frequently the means by which fungoid spores like those of *Trametes radiciperda* effect an entrance into the base of the trunk and the upper roots.

In order to obviate damage being done to the crop through careless felling, the work should preferably be done by the proprietor's own men under the superintendence of the forester; but where there is a large area to thin, it is sometimes found desirable to give out the work by contract, as it can generally be performed about 20 per cent. cheaper than by daily labour.

After the forester has marked every tree to be felled, the contractor should follow him with his men, and cut down and prune the trees; but he should in all cases be bound in a penalty not to injure any standing tree not marked to be felled. A removal contractor should follow him who fells the trees, and should extract all the felled stems to the nearest road; and he also should be subject to a penalty for any injury to standing trees. In thus doing the work by means of two contractors, it is accomplished at the cheapest possible rate within a given time; and if the operations are done under the eye of the forester or overseer, they ought to be satisfactorily executed.

It is usually well to enter into a contract for the sale of the thinnings before cutting the trees, so that the nett returns may be clearly calculated. Timber merchants are usually willing to purchase wood of every description, when it can be had in large quantities.

If the thinnings of a plantation are generally under propwood

dimensions, a rate per 100 or per 1000 may be agreed upon. But if they are of propwood size, *i.e.*, not less than 3 in. diameter at 6 ft. from the base, then they may be sold by the dozen, by the 100 trees, by the prop of 6 ft., or by the 100 lineal ft. as may be agreed upon. If they are above propwood size, but not classifiable as **timber**, *i.e.*, if over 6 in. but under 8 in. diameter at the small end, then they may be sold either individually or by the dozen, or by the 100; and if they are of timber size, it is best to fix the rate per cubic foot, according to the quality and kind, and the other local factors affecting the market value of the wood. In any case the purchaser should be bound to remove all the stems by a certain day, or, failing this, to incur a penalty. By adopting this mode of procedure, cut stems are not left lying unsold in the woods; while, at the same time, exact calculations can be made regarding the work in a manner that is hardly possible when the thinnings are carried out first and the produce is only sold afterwards.

In the disposal of thinnings in woods situated near populous districts, a public sale after the fall is generally found the best mode of realisation. The case is, however, very different in parts of the country at a considerable distance from any ready market; for foresters who have the management of extensive woods in far inland parts seem to have great difficulty in getting their thinnings disposed of advantageously, owing to their not making proper arrangements beforehand.

When timber merchants are asked to tender for wood already cut, and therefore in a perishable state, they will only offer far under its value; but when asked to give offers for standing trees, they know that the proprietor is not compelled to sell in the meantime unless he pleases, and they are therefore more disposed to tender a fair price.

Selling Timber.—Timber[1] may be disposed of either by **public auction** or by **private bargain**, as may seem advisable when local circumstances are taken into account; but, generally speaking, where there is a large quantity of timber to dispose of at once, and more especially when it is of a mixed character, the greatest amount of money will be realised by the proprietor when he disposes of it by public auction. At public sales there are in all cases people collected who are in quest of various sorts of wood, from the smallest size to the largest, consequently a competition takes place among them, which tends to the realisation of the proper value for each lot.

There are various methods of conducting sales: (1) by private bargain; (2) by calling publicly for tenders; (3) by exposing for auction at a reserve

[1] The scientific methods of ascertaining when timber crops attain maturity, and of allocating the annual or periodic falls of mature crops, are specially treated of in a brief manner by the editor in chapters xiii. and xiv.

price; and (4) by exposing for auction unreservedly. In different countries, and in different parts of each, one or other of these systems, or often two or more of them simultaneously, are to be found in operation at the same time. Local considerations alone can determine which method deserves the preference. And in the same way the timber may be sold either standing or in the log, each of which methods has advantages of its own that can only be weighed and balanced after due investigation into local circumstances in each concrete case. In Germany the usual method is to sell the felled timber; whilst in France sales of standing timber are very frequent.

Sales by Public Auction.—Suppose, for example, that the timber to be disposed of consists of thinnings of various sizes, taken from woods of different ages, and formed of different kinds of trees, and also that the felling is to be done by contract after the stems have been previously marked by the forester, then the **Contract for Felling** would probably run in something like the following form:—

CONTRACT FOR FELLING, CUTTING, AND PREPARING TIMBER FOR PUBLIC SALE ON THE ESTATE OF D———E, NOVEMBER 1894.

1. Only such trees are to be felled as are marked with (some distinctive mark); these will be pointed out to the contractor by A B, residing at the East Lodge, D———e.

2. All the trees marked in the park must be cut down with the cross-cut saw. In the young plantations the trees marked may be cut down with the axe, excepting those that are of or above 6 in. in diameter at the ground, all which must also be cut down with the cross-cut saw.

3. Each tree, previous to being cut over with the saw, must be laid in with the axe to the level of the surface of the ground, and then cross-cut to that level.

4. Any unmarked tree that may be felled, or any damage done to standing trees by the felling of the marked ones, or otherwise, shall be charged against the contractor at the rate of double the market value of each tree injured; and any damage to the felled trees arising through the carelessness of the contractor's workmen, shall also be charged against the contractor at a rate equal to the deterioration in value caused by such damage.

5. Each tree, as it is cut down, must be neatly cleaned of all side branches, and the bole laid entire along the side of the road, in order for sale—no cross-cutting of the bole being allowed.

6. The side branches, as they are taken from the trees, must be arranged into lots in order for sale, to the satisfaction of the above-named A B, or any person named by the proprietor.

7. All implements, as well as horses, &c., that may be required for the performing of the work, are to be furnished by the contractor.

8. All the trees marked (with the distinctive mark) are, after felling and trimming, to be arranged into lots for sale, in the manner above detailed, for the sum of 3s. per pound sterling of the amount of roup-roll; the whole work is to be finished and the timber to be in readiness for sale on or before the 26th day of December next.

9. All disputes or differences that may arise as to the due execution and fulfilment of this contract shall be referred to the determination of Mr J. O. (*forester* or *agent*), at M———h, whose decision thereon shall be final and binding.

E. F., *witness.* A. B., *Forester.*
G. H., *witness.* C. D., *Contractor.*

The overseer placed in charge of such work should see that each species of tree is arranged into separate lots by itself. No individual lot should contain less than 25 cubic ft. of timber, in order that there

may be a cartload for the purchaser; and each individual tree should be trimmed to its full length.

Observation at sales of timber will show that when large trees are cross-cut and logged to a particular length for the sake of convenience in having them removed from the interior of the wood to the side of the nearest road, they do not, as a rule, sell nearly so well as others of the same dimensions and quality which had been left entire. The reason is that, when purchasers of timber have the entire bole, they can apply it to many more purposes than short lengths; hence this is a point that should be borne in mind in preparing wood for sale, because the market value of timber may be prejudicially affected by injudicious logging.

Here again, however, it is only after full consideration of local circumstances that any sound opinion can be given in the matter. If, for example, a large local sawmill owner desires only timber that can be converted into scantlings, &c., he does not care to have to purchase top-ends of Spruce, Larch, Silver Fir, &c., and will not give so much for the logs if he is forced to buy what he does not wish in order to obtain what he really requires. Or if 18-ft. planking or 24-ft. beams have a constant good market, then 19 or 25 ft. logs will have practically no greater value to the sawyer than logs of the exact length; and for any purchaser who has a large contract for beams, &c., of given dimensions, it may often pay well to log to specified lengths.

All timber of good quality should be arranged in separate lots and sold separately from that of indifferent quality; and if possible, whatever number of logs or stems may be put into a lot, they should be of nearly equal size. For, where each sort is arranged according to its particular use and quality, the full market value of each lot will be more readily obtainable from different people who may have a use for that specific class of timber.

When trees are laid together in the way of lotting out for sale, the butts and tops should all be laid one way in a regular manner, so that the purchasers may see at a glance the size and quality of the wood exposed for auction.

All lots of wood prepared for public sale should be removed from the plantations and ranged along the sides of the nearest road, both for the convenience of purchasers and for the benefit of the woods themselves.

When coniferous logs in particular, and especially if unbarked, are allowed to lie long in the falls, they are apt to form breeding-places for noxious bark-beetles (*Scolytidæ*); and in crops of broad-leaved trees the subsequent removal of logs is apt to damage any young growth that may be on the area.

After the wood has been all arranged in lots, each lot should be numbered and entered in a sale-book, stating the kind of wood forming each lot, the number of trees in it, and the average value or upset price of the lot. Such a sale-book may be in the following form:—

SALE-BOOK OF TIMBER OFFERED FOR SALE AT B——— on the 15th November 1894.

Number on Lot.	Number of Logs in each Lot.	Contents. Cubic feet.	Kind of Timber.	Name of Purchaser.	Forester's Valuation (or Upset Price).			Actual Price Realised.		
					£	s.	d.	£	s.	d.
1	5		Oak	John Philip, Bonnyrigg	0	15	0	0	14	0
2	3		Do.	Do.	0	18	0	0	16	0
3	3		Do.	Do.	1	0	0	1	4	0
4	6		Do.	Do.	1	0	0	0	17	0
5	2		Do.	Robert Grindlay, Rosebery	1	6	0	1	10	0
6	7		Ash	Do.	0	12	0	0	13	0
7	11		Elm	R. Coldwells, Gorebridge	0	13	0	0	13	6
8	1		Larch	John Philip	0	18	0	1	2	0
9	1		Ash	M. Galbraith, Edinburgh	1	1	0	1	4	0
10	1		Do.	Do.	2	10	0	3	0	0
11	6 bundles		Firewood	T. Dalgleish, Gilmerton	0	3	0	0	3	6
12	6 do.		Do.	Do.	0	4	0	0	3	9
13	1		Elm	Thomas Johnson, Temple	1	8	0	1	15	0
14	1		Sycamore	John Philip	2	10	0	2	15	0
15	1		Do.	John Carrick, Glasgow	7	10	0	8	12	6
16	1		Larch	John Philip	2	15	0	3	0	0
17	1		Do.	Do.	3	15	0	4	5	0
18	1		Ash	M. Galbraith	8	15	0	12	0	0
19	1		Beech	A. Easton, Falkirk	2	0	0	1	15	0
20	8		Spruce Fir	John Philip	1	4	0	1	0	0
21	7		Beech	R. Coldwells	0	10	0	0	6	0
21 lots	62 logs 12 bundles	Cubic feet	...	Totals . .	41	7	0	47	9	3

Such a forester's sale-book is often very useful as a guide in arranging sales of timber by private bargain or by tender.

It is, of course, requisite that the length, mean girth, and cubic contents of each log must be registered, either in a sale-book or in a separate register, for information; otherwise such a meagre statement as the above record will fail to convey all the information that it is desirable to have in a handy and explicit form.

Public sales of wood should be well advertised, for general information, during the two or three weeks previous to the day of sale, so that time may be given for its being properly made known. The following is a convenient form of advertisement for such a sale as has just been referred to in the above sale-book:—

SALE OF WOOD.

There will be sold by Public Roup,

ON THE ESTATE OF B——Y,

Near A——,

On Friday, the 15th November 1894,

A large quantity of Timber, consisting of Sycamore, Ash, Larch, and Beech, of large dimensions; a considerable quantity of Oak adapted for trams, spokes, and other country purposes; Ash for handle-wood; Larch, Scots Pine, and Spruce Fir, fit for deals, roofing, railway-sleepers, &c.

J. C., plantation Overseer at W—— village, will point out the timber to intending purchasers.

The above will be exposed for sale in lots to suit purchasers. The Sale will begin at C—— Bridge, near W—— village, exactly at ten o'clock in the forenoon.

B——Y, *October* 27, 1894.

In order to obtain full publicity, such an advertisement should be inserted in two or more of the local newspapers, printed forms being also put up along the public thoroughfares, and sent to people who are known to be in the habit of buying wood.

When all the wood intended for sale has been cut, arranged, and advertised in the above manner, the forester should arrange the articles and conditions of sale with the auctioneer. Such articles and conditions, which must be read at the commencement of the sale, may run in the following terms:—

ARTICLES AND CONDITIONS OF SALE OF WOOD ON THE ESTATE OF B———Y, to be exposed for Sale on this 15th day of November 1894.

1. The wood to be put up in lots, and at such upset prices as the forester or auctioneer may think fit, and sold to the highest bidder, who shall be bound to conform to the following conditions:—

2. Each lot to be at the entire risk of the purchaser thereof as soon as knocked down by the auctioneer; but none of the lots may be removed before a settlement for the same has been made to the satisfaction of the seller of the timber or his agent.

3. The owner reserves to himself the right of making one bid for each lot, and also the power of adjourning the sale if he shall see cause.

4. Any damage done to the plantations, gates, or fences in the removal of the wood from the ground or otherwise shall be paid for by the purchaser against whom such loss or damage can be proved, the master being always accountable for his servant.

5. Purchasers shall be allowed six weeks from the day of sale for the removal of their purchases; and should any purchaser fail in having his purchases removed by the time above specified, he shall forfeit his offer of purchase, and be liable to the exposer in one-fifth part of his offer of purchase in name of penalty; and the exposer shall have it in his power to do with each lot or lots as he may think proper for his own benefit; but the first offerer shall remain bound for any deficit below the original price.

6. Purchasers, if required, shall pay to the clerk of sale one-fourth of the price of each lot as a deposit.

7. All sums at and below ten pounds sterling are to be paid for in ready money; but for all sums above ten pounds, three months' credit will be allowed on bill and caution being granted to the satisfaction of the exposer or his agent.

8. Purchasers will have to meet with the seller's agent on Wednesday the 20th next, between the hours of twelve and two o'clock, in the B——y estate office, in order to settle for their purchases. Those who prefer to do so can make their payments in full to the agent immediately on the conclusion of the sale.

9. Purchasers are required to pay the legal costs of any bill stamps required.

10. T. D. is hereby appointed the seller's agent, with full power to settle all differences that may arise between the purchaser and exposer, or between the purchasers themselves; and his decision shall be final and binding.

In witness whereof,

(Signed) _____

For large and important sales of standing timber the forester should only arrange through the estate agent, and should be careful to have the advertisements and articles of sale duly submitted to and approved by the competent legal advisers of his master.

For such more important sales of standing timber the advertisement and articles of sale would possibly be as follows (subject, of course, to the scrutiny and correction of the owner's lawyers):—

SALE OF TIMBER

IN THE FOREST OF DALABA, NEAR S———A.

There will be exposed to sale by Public Roup, on Friday the 27th current,
Within the COURT-HOUSE, S———A,
At Eleven o'clock forenoon,
20,000 Standing Trees of Larch and Scots Pine, fit for railway-sleepers, boards, &c.
The trees are divided into 40 different lots of various sizes to suit purchasers.
J. T., forester of the district, will point out the lots previous to the day of sale; and further particulars may be learned on application to J. B., agent to Sir A—— S——, at Dalaba.

DALABA, *March* 4, 1894.

Previous to issuing such an advertisement, all the trees intended for sale should be marked and numbered, keeping each lot separate, so that all the trees in each can be properly distinguished from those of the other. The marking may begin upon one side of the district purposed to be cleared, and continue successively from side to side, till the whole number of trees forming the first lot has been marked. Then the second lot is marked in like manner, taking care to make the marks of the trees of this second lot upon the opposite sides of the trees from those of the first; and so on with all the other lots, keeping all the marks of any one lot upon one side, and reversing them alternately for the various different lots.

As the forester is marking every individual tree in each lot, he should estimate and enter its value into a sale-register, so that he may know the total value of the trees forming each lot, and can judge whether a fair value is being offered for each lot as it is put up.

There are various modes of marking standing timber that is to be exposed for sale. The method that used to be practised by the author was as follows:—Beginning with lot No. 1, a man with an axe takes a slice from the side of the tree intended to be marked, and makes it deep enough to take the bark clean off, with a thin slice of the outer wood. This done, another man follows with a piece of *red keel*, and marks $\frac{1}{1}$ on that part of the tree from which the slice was taken. The man with the axe proceeds to the second tree and removes a similar slice from it, when the man who follows him with the keel marks $\frac{2}{1}$ on it, and on the third tree $\frac{3}{1}$, and so on with all the trees in the lot. When they have finished marking and numbering the trees in the first lot, they proceed to the second, of course taking care to mark the trees $\frac{1}{2}$, $\frac{2}{2}$, $\frac{3}{2}$ on the opposite side from that of the first lot, and so on with each lot as the numbers rise. In this mode of numbering, $\frac{1}{1}$ represents the first tree of the first lot, $\frac{2}{1}$ the second, $\frac{3}{1}$ the third, and so on with all the trees of the first lot, so that the last tree of the first lot will, in the instance under notice, be $\frac{500}{1}$, which means the tree numbering 500 of the first lot. And similarly with the

numbers on the second lot, $\frac{1}{2}$ means the first tree of the second lot, $\frac{2}{2}$ the second; and in the same way all the trees of each lot are successively numbered from 1 to 500 each in the order of its lot, so that the intending purchasers can easily see to which lot the trees before them belong. All this obviates trouble afterwards. While the men are engaged in marking and numbering the trees, the forester follows them and notes down their dimensions, contents, and value respectively. In this way any number of trees may be easily marked, valued, and disposed of with a fair degree of correctness and in a satisfactory manner.

The cubic contents may most easily be calculated by means of the methods described in chapter xiii., page 355.

When all the trees are marked, numbered, lotted, and in every respect prepared for sale, the articles of roup must be prepared and drawn out on stamped paper by the estate agent before the sale commences. They will probably run in something of the following style:—

ARTICLES AND CONDITIONS OF ROUP AND SALE OF LARCH AND PINE TIMBER IN THE FOREST OF DALABA, THE PROPERTY OF SIR A. S.

To be exposed to sale by Public Roup, at the sight and instance of J. B., agent to the said Sir A. S., within the Court-House of S——a, this Twenty-seventh day of March Eighteen hundred and ninety-four, at Eleven o'clock forenoon.

1. The said timber will be exposed to sale by public roup in ten different lots, or in one or more lots, and during such space of time as the judge of sale hereinafter named may determine, at a certain upset price per lot; and the person offering the said upset price, or, in the case of more offerers than one, the highest offerer, shall be preferred to the purchase.

2. In case several offers shall be made for any lot or lots so put up, every subsequent offer shall be at least one pound sterling more than the preceding offer when under fifty pounds, two pounds when above fifty pounds and under one hundred pounds, and five pounds when above one hundred pounds; and each offerer shall subscribe his offer, if required by the judge of sale, and become bound for the sum offered by him in terms and upon the conditions of these articles.

3. The person preferred to the purchase of any lot or lots shall have right thereto after paying or otherwise settling for the same in terms of these articles, and the purchase-money shall be paid to the said J. B., as exposer foresaid, in manner following: The purchaser shall pay down into the hands of the clerk of sale hereinafter named one-third part of the purchase-money in part payment of each lot, within fourteen days from the date of sale (which third part shall bear legal interest thereafter till paid), and shall grant bills for the balance of price with security to the satisfaction of the exposer and judge of this sale, payable to S——a, by equal instalments, at three and six months from the date of sale. Acceptors of bills to pay the stamps; and no part of the timber will, on any pretence whatever, be permitted to be interfered with or taken into possession by purchasers until paid for in cash, or otherwise duly settled for agreeably to these articles; all within the said space of fourteen days from the date of sale.

4. For all cash payments in full, discount at the rate of five per cent. per annum will be allowed, if paid within the said space of fourteen days.

5. The timber shall be felled, logged, converted, and removed at the expense of the purchaser before the thirtieth day of May Eighteen hundred and ninety-five; but in the

event of any one purchaser buying the whole of the timber exposed for sale, such purchaser shall be allowed two years from the date of sale to clear and carry away his purchase from the forest—the proprietor, the said Sir A. S., his heirs and executors, always retaining and reserving to himself and his foresaids a right of lien or hypothec prior and preferable to all other parties whatever over the timber sold in the forest until the purchasers' bills or purchase-prices are duly paid; and any person failing to clear the forest of his purchases within the time prescribed shall forfeit and lose whatever timber belonging to him may be found in the forest after the expiry of the time allowed for removal, and the same shall revert and return to the said Sir A. S., or his foresaids, to be used or disposed of by him or them at pleasure. Purchasers will be allowed to erect sawpits, sawmills, and other accommodation for manufacturing their timber, in such places as the surveyor shall allow.

6. Purchasers are hereby taken bound to keep at all times the roads and accesses to and in the forest clear of obstructions, and not to do any injury to any tree or trees reserved from sale within any lot, or to those on any other portion of the forest; and no purchaser shall be permitted, on any pretence whatever, without the written permission of the surveyor of the forest, to light fires within the forest except for steam-machinery; and in the event of the reserved trees being in the least damaged or destroyed by the purchasers or those in their employment, the purchaser shall be bound to take the whole of the trees so damaged at the rate of five shillings sterling per cubic foot, according to the forester's measurement.

7. The lots, after the sale, shall be at the sole risk of the respective purchasers thereof; but no lot shall be taken possession of by the purchaser without written authority under the hands of the surveyor of the forest; and any person presuming to interfere with the lots, directly or by means of any other person or persons, without such written authority, shall be considered a wilful trespasser, and may be prosecuted as the law directs.

8. The trees constituting each lot are carefully, and believed to be correctly, numbered and described; and the purchasers are to take the same as numbered and described in the roup-roll appended to these articles, without being entitled to any compensation or abatement from the price offered and accepted, by reason or on account of any deficiency or mistake, alleged or real, in number, quantity, quality, or description, it being understood that parties have satisfied themselves as to these considerations previous to the day of sale.

9. Any purchaser failing to pay the said third part of the value of his purchases, and to grant a bill of security as aforesaid therefor, shall, in the option of the judge of this sale, not only forfeit his interest in and right to the purchase, but shall be liable to the exposer in one-fifth part of the price offered by him, in name of liquidate damages, which shall in no event be modified; and it shall be optional to the exposer either to hold the said purchases himself, or to re-expose the same to sale.

10. In the event of there being no competition, or no one offering the upset price for any lot or lots put up to sale, power is hereby reserved to the judge of the sale to reduce the said upset price, and again to expose the said lot or lots to public roup, at such upset price, and under such alterations or modifications of these conditions as he may think fit.

11. The exposer reserves to himself one offer on each lot previous to being struck out by the auctioneer of the sale.

12. H. D., licensed auctioneer, residing in S——a, is hereby appointed auctioneer of this sale; J. C., residing at D——, near S——a, clerk thereto; and the said H. D. is appointed judge thereof, with power to adjourn the same from time to time in regard to part or the whole of the timber, and, with or without adjournment, to reduce the upset price, to alter or modify these articles and conditions, and to determine all questions or disputes that may arise in connection with this sale, between the exposer and the offerers or purchasers, or amongst the offerers themselves relative to the premises in any manner of way; and the said Sir A. S., by the subscription of these presents on his behalf, and the offerers by subscribing their offers on the roup roll, are hereby taken bound respectively to fulfil the articles and conditions to each other under the penalty of two hundred pounds sterling, to be paid by the party failing to the party performing or willing to perform the same, over and above performance; and both parties consent to the registration hereof, and of the roup-roll or minute of roup, decerniture of the judge, and minute or minutes of enactment, in the Books of Council and Session, or others competent, therein to remain for preserva-

tion; and if necessary, that letters of horning on six days' charge, and all execution needful, may pass on a decree to be interponed hereto in common form, and thereto constitute their procurators, &c.

In witness whereof, these presents, consisting of this and the two preceding pages of stamped paper, written by J. B., clerk to A. B., Writer in S——a, are subscribed by the said J. B. on behalf of the said Sir A. S., at S——a, the twenty-seventh day of March Eighteen hundred and ninety-four, before these witnesses, D. G., clerk to the said A. B., and Robert Smith, clerk to the said A. B. (Signed) J. B.,

D. G., *witness.* For Sir A. S.

R. S., *witness.*

Besides such articles and conditions of sale as the foregoing, it will be necessary to have another document prepared previous to the proposed sale; this is therein referred to as the roup-roll, which must be appended to the articles of roup. It is merely an abstract account of the several lots, which also shows the prices obtained for them at the sale. A convenient form of roup-roll is here exhibited:—

ROUP-ROLL OF PINE AND LARCH TIMBER IN THE FOREST OF DALABA, sold within the Court-House, S——a, 27th March 1894.

No. of Lots.	Description of Trees.	Number of Trees in each Lot.	Names and Residences of Purchasers.	How settled.	Price. £	s.	d.	Sums paid. £	s.	d.
1	Scots Pine.	2000	Colin Archibald, Aberdeen, *Eight hundred pounds.* (Signed) C. Archibald.	One-third paid, and remainder settled by bill.	800	0	0	266	13	4
2	...	1500	P. Grant, Grantown, *Six hundred pounds.* (Signed) P. Grant.	Do.	600	0	0	200	0	0
3	...	1000	J. Robertson, Grantown, *Four hundred pounds.* (Signed) J. Robertson.	Do.	400	0	0	133	6	8
4	...	3200	John Yule, Newburgh, *One thousand four hundred pounds.* (Signed) J. Yule.	Do.	1400	0	0	466	13	4
5	...	4300	R. Urquhart, Forres, *One thousand six hundred pounds.* (Signed) R. Urquhart.	Do.	1600	0	0	533	6	8
6	...	800	J. M'Pherson, Dunkeld, *Three hundred pounds.* (Signed) J. M'Pherson.	Do.	300	0	0	100	0	0
7	...	2500	R. Nicholson, Newcastle, *One thousand five hundred pounds.* (Signed) R. Nicholson.	Do.	1500	0	0	500	0	0
8	...	1200	J. M'Kenzie, Perth, *Four hundred pounds.* (Signed) J. M'Kenzie.	Do.	400	0	0	133	6	8
9	Larch.	1500	A. Oswald, Perth, *Nine hundred pounds.* (Signed) A. Oswald.	Do.	900	0	0	300	0	0
10	...	2000	John Yule, Newburgh, *One thousand five hundred pounds.* (Signed) J. Yule.	Do.	1500	0	0	500	0	0
		20,000	Total amount of sale		£9400	0	0			
			Paid on day of sale					£3133	6	8

In an extensive transaction of this kind, the exposer should cause every purchaser of a lot to subscribe the roup-roll as the lot is knocked down to him. This prevents misunderstandings afterwards, and gives the proprietor of the timber a legal hold upon the purchaser that he could not otherwise have.

Coppice-woods are generally sold by the acre, or they may be sold in lots of any given convenient acreage, which should be all valued previous to the day of sale. Sales of Oak-coppice may very conveniently take place in the month of February or March, with the proviso that all the stripping is to be completed before the end of May.

Sales by Private Contract.—In selling timber by private bargain, a certain rate per cubic foot or per tree is usually fixed according to kind and quality,—or so much is named for a certain number of trees, in which case the trees must of course have been previously valued both by the forester and the purchaser. In other cases, where a large quantity of timber is to be disposed of by private bargain, tenders may be invited from different parties, and the sale may take place either to the person who offers the highest price for the whole, or to those who offer most for each individual lot.

In any large transaction of this kind, it is necessary to have a proper form of agreement drawn out on stamped paper, and signed by the parties before witnesses; for, without such an agreement, even although the price should be paid in advance, misunderstandings are apt to arise, which may terminate in lawsuits. But when a proper stamped agreement has been entered into and duly witnessed, both parties have their rights and duties plainly set forth for mutual guidance. The following exhibits such a form of agreement; here again, however, it is necessary that the forester should place the matter entirely in the hands of the estate agent:—

CONTRACT OF SALE BETWIXT A. B., FOR SIR J. R., AND J. R. & W. M., TIMBER MERCHANTS, E———D.

It is hereby contracted and agreed between A. B., residing at R———e, near G———n, wood-manager to, and for behoof of, Sir J. R., and duly authorised in the premises, on the one part, and J. R. & W. M., timber merchants at E———d, on the other part, in manner following:—That is to say, the above parties, considering that the said J. R. & W. M. have offered to the said A. B., acting for the said Sir J. R., the proprietor, for twenty thousand Scots Pine trees, standing in the forest of R———n, partly on R———n Braes, and partly on the west side of Tor Hill, all as already marked off and pointed out, the total sum of Two thousand nine hundred and eighty pounds and fourteen shillings sterling, which offer the said A. B., acting foresaid, has accepted upon the terms and subject to the conditions hereinafter set forth; and as it is necessary to enter into a contract of sale containing the usual and necessary clauses, therefore the said parties have contracted and agreed as follows:—

1. The said twenty thousand trees shall be, by the district forester, made into lots of various sizes, and for the first lot, containing seven thousand nine hundred and twenty-

eight trees, the said J. R. & W. M. bind and oblige themselves to pay at the rate of five shillings and sixpence for each tree; for the second lot, containing two thousand three hundred and forty-four trees, at the rate of five shillings per tree; for the third lot, containing eight thousand and thirty trees, at the rate of sixpence per tree; and for the fourth and last lot, containing one thousand six hundred and ninety-eight trees, at the rate of twopence per tree; the aggregate price of which several lots amounts to the foresaid sum of two thousand nine hundred and eighty pounds and fourteen shillings sterling.

2. The said J. R. & W. M. bind and oblige themselves forthwith, and before they have right in any way to interfere with any part of said twenty thousand trees, to pay to the said A. B., for behoof foresaid, the sum of nine hundred and ninety-three pounds eleven shillings and fourpence sterling, being one-third part of the purchase-price of said timber, and to grant a bill with security to the satisfaction of the said A. B. for remaining two-thirds, payable in G———n, by two equal instalments, at six and twelve months from the date of these presents.

3. It is contracted and agreed that the purchasers shall have, from the date of these presents, three years to remove their purchase from the lands of the forest; and they bind and oblige themselves, and their heirs and successors, to remove the said timber by such roads and accesses as shall be pointed out by the said A. B. or the district forester; and further, the said J. R. & W. M. bind and oblige themselves, during said period of three years, to keep clear of all obstructions the roads and accesses to and from and in the forest, to be used by them, and to pay one-half the sum required for making new roads for their exclusive use, and a like proportion of the sum necessary for repairing roads made to be used by them.

4. It is contracted and agreed that the said J. R. & W. M. shall have a site for a sawmill on the farm of R———n, where pointed out; and they bind and oblige themselves and foresaids to remove from said mill and mill-site at the first term of Whitsunday after the expiration of said period of three years, and that without any summons of removing or process whatever.

5. The said J. R. & W. M. bind and oblige themselves and their foresaids to pay for any damage done by them or their servants to timber standing or lying in or near the forest, not forming part of their purchase, double the value of such timber, and the same shall, notwithstanding such payment, remain the property of the original owner. And the said J. R. & W. M. further bind and oblige themselves not to interfere with or break down any part of the forest enclosures in the course of their operations, without the sanction of the district forester, and then upon such conditions as shall be stipulated by him.

6. It is contracted and agreed that the said J. R. & W. M. shall be responsible for damage done by fires kindled within the forest, by themselves or their servants, without the sanction of the forester.

7. It is specially contracted and agreed that the said Sir J. R. and his foresaids shall, during the currency of the bill to be granted for two-thirds of the purchase hereby made, as before provided, have a right of lien or hypothec over any part of said purchase on or near to the lands of the forest, prior and preferable to all other creditors of the purchasers; and it is further agreed that, should the purchasers fail in the observance of any of the conditions stipulated by this contract, it shall be in the option of the said A. B. or Sir J. R.'s wood-manager for the time, upon such failure, either to permit this contract to remain obligatory, or to declare it at an end, and forthwith to eject and remove the purchasers and their foresaids, and all others acting in their name, from the lands of the forest, and from said mill-site, and to enter upon possession of the same, and that without any declarator or process whatever; and it is hereby declared that the purchasers shall be held to have failed in their said obligations, in the event that they shall not duly pay the instalments of the price falling due under the bill to be granted as before provided; and,

8. Both parties, the said A. B. for Sir J. R., and the said J. R. & W. M., bind and oblige themselves to implement this contract to each other under a penalty of Two hundred pounds sterling, to be paid by the party failing to perform to the party performing, or willing to perform, over and above performance; and both parties consent to the registra-

tion hereof in the Books of Council and Session, or other Judge's books competent, therein to remain for preservation, and that all necessary execution, on six days' charge, may pass upon a decree to be interponed hereto in form as effeirs; and to that effect they constitute their procurators, &c.

In witness whereof, these presents, written on this and the three preceding pages by A. B., Writer in G———, are subscribed as follows—viz., by the said A. B., at G——n, the eighteenth day of March Eighteen hundred and ninety-four years, before these witnesses, namely, A. L. his head clerk, and H. B., his clerk, and by the said J. R. & W. M., at E———d, the twenty-third day of March, year last mentioned, before these witnesses, namely, A. H., banker, W———l, and A. M., accountant there.

		(Signed)	A. B.
A. L., *Witness.*	A. H., *Witness.*	(,,)	J. R.
H. B., *Witness.*	A. M., *Witness.*	(,,)	W. M.

Sales of Converted Timber.—If any forester who is, say, in the habit of getting 1s. 2d. per cubic ft. for Larch timber sold lying in the woods in the round, has also charge of a sawmill, at which he wishes to cut up Larch for sale to various dimensions of scantlings of the best marketable dimensions, he should of course calculate what minimum rate he must obtain per cubic ft. of sawn timber so as to get any profit by the conversion. Supposing, for example, that he has 150 cubic ft. of Larch timber lying cut about a mile distant from the sawmill, and that it is valued at 1s. 2d. per cubic ft., or £8, 15s. for the lot, then he must consider at what rate per cubic ft. this Larch should be sold, after being carted from the woods and cut up at the mill, so as to realise the original price, cover all necessary expenses, and realise a small profit on account of the extra trouble and expense connected with the operation of conversion.

The expenditure incurred in dragging and converting the logs will probably be about the following:—

To 2 horses and carts, drawing 150 ft. of Larch from the woods, 1 mile distant from the sawmill, at 6s. per day for each horse	£0	12	0
To 1 man assisting in loading carts, at 2s. 6d. . . .	0	2	6
To 4 men in sawmill 1 day, cutting up the same into scantling, 6 × 2 in., at 3s. per day each	0	12	0
To keeping up machinery of mill, files for saws, oil, &c. &c. &c. .	0	18	0
	£2	4	6

Here the outlay necessary for converting the 150 ft. of rough wood into scantling at the sawmill amounts to nearly 4d. per cubic ft.; hence he will have to calculate the original cost of the wood at 1s. 6d. per ft. in order to be in the same financial position as formerly.

But 150 cubic ft. in the round may only yield 100 to 120 ft. of scantling; hence he will have to get 2s. 2½d. per cubic ft. in the former case, and 1s. 10d. in the latter, merely to cover the additional outlay, and be in the same financial position as before. Any excess over these rates will be profit on the transaction, as also will be any returns available from the sales of the slabs as firewood, &c. With regard to the loss by conversion, Gayer (*op. cit.*, p. 536) says that, whilst it varies very greatly according to the nature of the

conversion, it may generally be assessed at from 30 to 50 per cent. And the editor found that in sawing operations, involving the conversion of many thousands of fine round logs of Ironwood into narrow-guage sleepers in Burma, there was an average loss of about one-third on the true measurement of the logs (length multiplied by mean girth).

Again, supposing the forester gets an order for a quantity of 4 in. × 1 in. paling rails of Scots Pine, also that he can sell Scots Pine of the size adapted for paling at 8d. per cubic ft. in the rough, and that the extra outlay for bringing the wood to the mill and converting it will come to 4d. per ft., as in the former case, then the price of the sawn wood will be 1s. per cubic ft. This will, of course, be on the original measurement, and any loss in bulk by conversion must be balanced by a corresponding enhancement in the selling price of the converted timber.

The Felling of Timber.—In thinning woods of considerable age, or in clearing a mature crop, the felling of timber-trees may be performed either by the proprietor's own woodmen, or by daily labour, or by contract, according to the special circumstances of each case.

In thinning woods consisting of a valuable and promising crop, it will generally be found desirable to have the work done by the proprietor's own men, and under proper supervision, as the forester or overseer is more likely to see that the operations are performed in such a manner as not to injure the standing crops.

But, where the work consists in the clearance of old and mature timber, it will often be found more economical to have it done by contract than by employing men on daily labour; and this sort of work may be contracted for either at a certain rate per tree, or at so much for the cutting of the whole number of trees to be felled.

Serious disputes sometimes arise between proprietors and wood-merchants, when the former sell their timber to the latter on the understanding that it is to be felled for them in a certain manner and within a certain time; hence a proprietor should not undertake to fell trees for a timber merchant, for the latter often tries to discover ways and means to obtain some reduction in the stipulated price, by finding fault either with the mode of doing the work, or with regard to its completion within the time specified. It is therefore often better to arrange that the timber merchant shall cut, log, and remove the timber himself, but to bind him to do the work of felling to the satisfaction of the forester, and within a given time.

The editor cannot join in the author's recommendations. If the area to be felled consists of a total clearance, say of Spruce or Scots Pine for artificial regeneration by means of planting, then it is practically immaterial by whom the fall of the timber is made; but if the fall is taking place over areas that are in process of natural reproduction, as would often be the case in properly managed woods of Oak, Beech, Scots Pine, Larch, and Silver

Fir, then no method can be recommended except that felling operations be conducted by the proprietor's own woodmen acting under the direct supervision of the forester or wood-bailiff. Damage to the seedling-crop is almost necessarily unavoidable to a greater or less extent; yet it is most likely to be reduced to a minimum when the full control and the responsibility for the conduct of the operations rests entirely with the forester.

That the forester should then, with regard to the actual work of felling, endeavour to meet the wishes or suggestions of the timber-merchant, is, or should be, a matter of course; for the mutual interests of both lie in being reasonable and accommodating. Over-reaching on the part of any wood-buyer would be sure to defeat itself ultimately.

When the timber is sold by measurement at a certain rate per cubic ft., a proper and clear understanding should be entered into, as to—

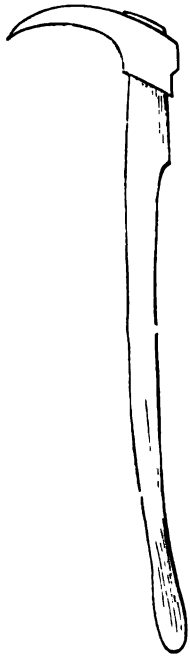
(1.) The allowance to be made for the thickness of the bark;
(2.) What size of branches is to be measured as timber;
(3.) How far out to the small ends of the trees the measurements are to be taken;
(4.) The allowance to be made for any unforeseen rot or other deficiency in the trees; and
(5.) Whether the branch wood is to belong to the proprietor or the timber merchant.

Very important disputes may arise on any of these points. Unless, in the case of selling by measurement, the forester guard himself by previously entering into a proper understanding with the wood-merchant on all these matters, the latter may take advantage of him, and in all probability get the best of the dispute. All differences on specified points, however, can be obviated by selling at a certain rate per tree, or at so much for the whole lot of trees to be disposed of; and if the timber be carefully valued beforehand, this is often the better arrangement for all parties.

Whether timber be felled by the proprietor's own woodmen or by the purchaser, the forester should compel the men to cut the trees as low as possible, both in order to ensure the largest possible quantity of timber being realised from them, and to prevent large stumps remaining. This object can be always materially assisted by clearing away the turf or earth from the base of the trees with a spade, and thus removing anything that may be likely to interfere with the axe and saw in the operation of felling low, also by trimming or hewing well down with the axe all the tops of the roots standing up and projecting like buttresses above the ground in forming the junction with the stem. This should be done to such an extent that the circle of the stem of the tree to be felled shall be equal down to the earth, when it can be cut through with the cross-cutting saw in the usual way.

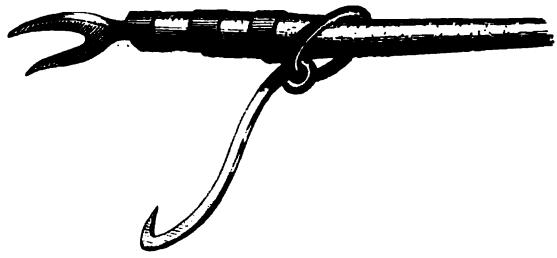
Singular as it may seem that timber merchants should fell their trees in such a way as to leave about 6 to 12 in. of the butt end of

Fig. 272.



Krempe or Sapine.

Fig. 274.

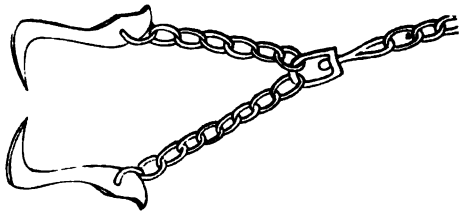


Gripper and Turning-Hook.

Fig. 273.

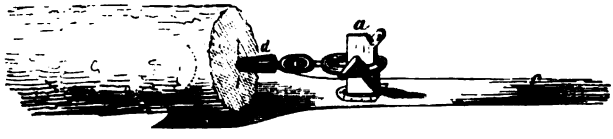
Floating-Hook.

Fig. 275.



Dragging Clip or Shears.

Fig. 276.



Dragging Pin.

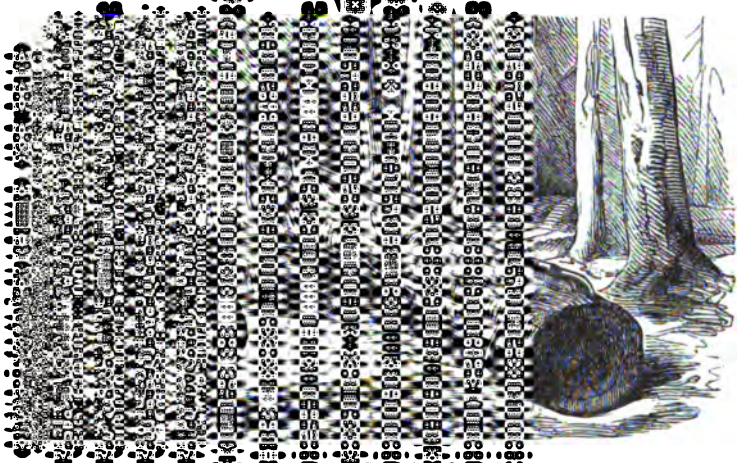
Fig. 277.

Dragging Shoe.

each stem standing above ground on the stocks, still it is a fact that they generally do so when left to themselves as regards felling. This

[illegible] ral knowledge in the [illegible] ing imposed upon by [illegible] rmance of the work, [illegible] a desire to have the [illegible] s therefore necessary [illegible] nterests in this matter. [illegible] stock, this will mean a [illegible] f timber. And where [illegible] the loss will probably [illegible] ry; hence the neces- [illegible] ear small matters.

[illegible] er are exhibited in Figs. [illegible] toothed-hook known as [illegible] France. The purchase



[illegible] *se.*

[illegible] which he has driven its [illegible] d. Fig. 273 represents [illegible] g pole, and used more [illegible] Fig. 274 exhibits the [illegible] hich is clearly illustrated [illegible] or shears, for catching [illegible] en to the nearest road- [illegible] pin and the shoe, used [illegible] he dragging shears.

[illegible] *ime for conducting fell-* [illegible] n in sylviculture, to a [illegible] cal circumstances in par- [illegible] , with the exception of [illegible] the most active flow of [illegible] should not be conducted [illegible] months, when, even in

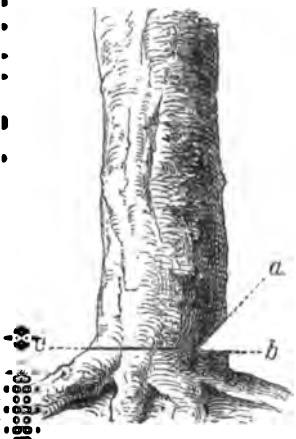
nly too often in want of employment. heavy snowfall prevents work in the ing winter, and practically restricts er seasons of the year; but in Britain o prevail. And it is a well-known fact e wood is better, but also that less ths and neighbouring trees when the ernal period of non-active vegetation. of view, it seems to the editor that fall of the leaf, must be the most quality of the wood is concerned; for ths the cambial layers of the stem ses from the soil by capillary attrac- mperature in spring, the flushing of indicate the re-awakening of active hum of moisture in the tree must ter the fall of the leaf; hence from he time at which there is the maxi- oisture in the stem, *i.e.*, probably at f July or the beginning of August, summer flush of shoots and foliage e technical quality of the wood will decline, whereas from that same time inimum point is again reached it will improve. Other considerations also be taken into account; for in wood ummer when containing a maximum re, and exposed to the highest tempera- e year, the shrinkage both diametrally entially will be considerably greater ny other time of the year, *i.e.*, there more damage done in the way of acks and star-like flaws at the ends g. In the autumn felling the tech- ry to the wood from evaporation and will of course be least, owing to the ve indicated.

take place in the manner indicated in by making out a wedge-shaped tem is desired to be thrown, and as etrate as far as, or slightly beyond, The second cleft, *b*, must be made hould be so laid in that the apex of me above that formed by *a*. When t the stem falling in the exact direc- inserted into *b*, and then a wedge riven home the stem is forced over. oodmen in Germany can make stems felling large timber trees of valuable he roots are often cut through and w the workmen to lay in with the axe

only take place in the case of small the opposite side to which the fall is over. But with larger trunks a cut

fall is desired, and to a
then a second cut on the
etrated to some depth,
orking freely, and then
t open. These wedges,
, at the same time act
e on which the fall is
fall is accomplished.
cally the best method.
d in Fig. 280. A cleft,
iameter of the stem, is

Fig. 280.



lling with the Axe and Saw.

to 7 per cent., and in

reckoned to the different
(*ibid.*) :—

od amounts to 4 per cent. of
other smooth-barked trees of
arked trees of broad-leaved
d 15 to 18 per cent. in Larch

inly that generally most
y steep hill-sides, or for
n all round about even
nd, of course, in thick
yed where there is not
timber-saws.

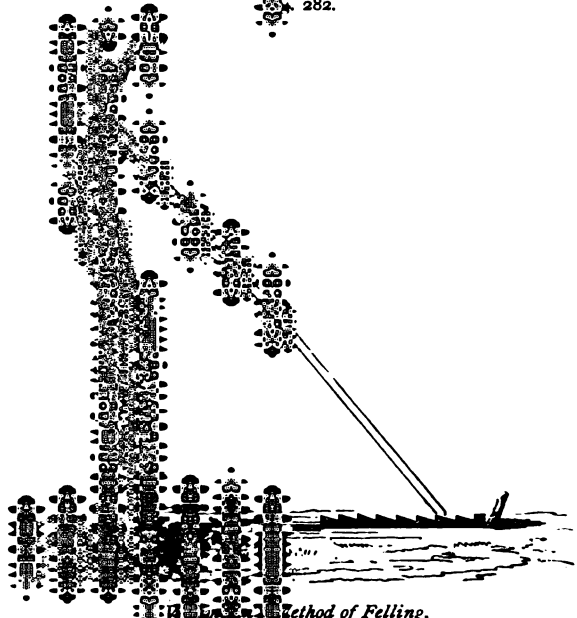
purchase and leverage
operations. Fig. 281
rest, where felling takes
of the stem in a parti-
ave been laid in at the

[illegible] 279), wooden wedges are put into the [illegible] means of a stout pole, *m*, into which

281.

[illegible] *onifers in Felling with the Axe alone.*

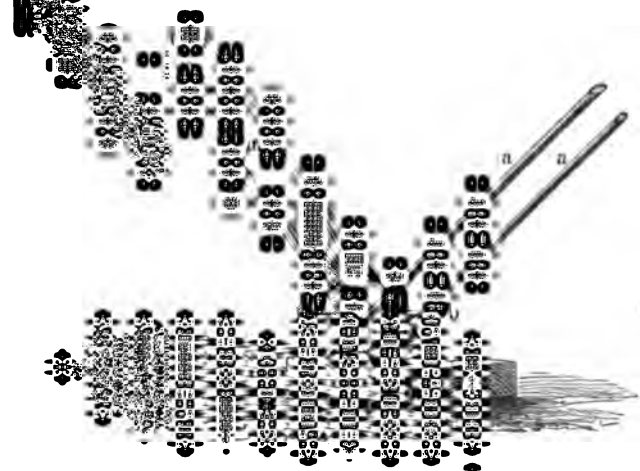
282.



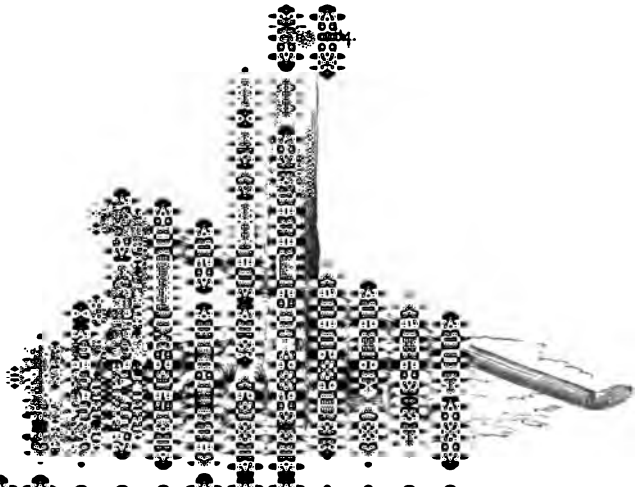
[illegible] *ethod of Felling.*

[illegible] by means of notches at *a* in the stem [illegible] (Figs. 282 and 283) is simply a develop-

[illegible] er the roots have been [illegible] s applied by the levers [illegible] a sort of rack-base *z*, [illegible] me firm and convenient



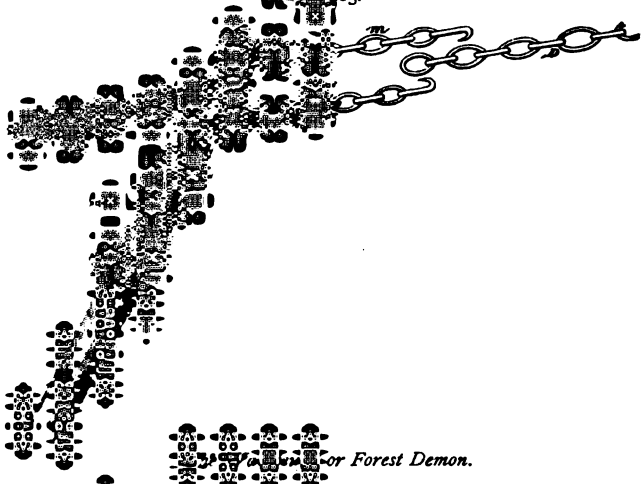
[illegible] e practical effect of this [illegible] ten times greater than [illegible] mon timber-jack is also



[illegible] represented in Fig. 284, [illegible] own trees that have been [illegible] ry old instrument known

[illegible] Forest Demon (Fig. 285), an instrument [illegible] ling stumps out of the ground. It [illegible] *m*, attached to a stout tough pole, *c*, [illegible] like a large tree by a mooring chain, [illegible] the main chain, B, attached to the [illegible] over—as, for example, around some [illegible] lever C successively or alternately,

Fig. 285.



[illegible] or Forest Demon.

[illegible] *mm* can gradually be moved forward [illegible] id iron chain, of course, means that [illegible] to the distance of one link each time, [illegible] trivance is brought into play simul [illegible] w, it very effectually assists the felling [illegible] ly takes this opportunity of recom-

Fig. 286.

[illegible] sters and landowners. Both in this [illegible] trivance, the high effect produced is [illegible] n of force; and of course the higher [illegible] ents can be brought into play, the [illegible] ntly the more effective is the result [illegible] ts.

[illegible] teufel was originally used principally

Other more direct
ibited in Figs. 286 and
eration is usual in the
lone.

Tree-Felling Machine

3 ordered to clear an
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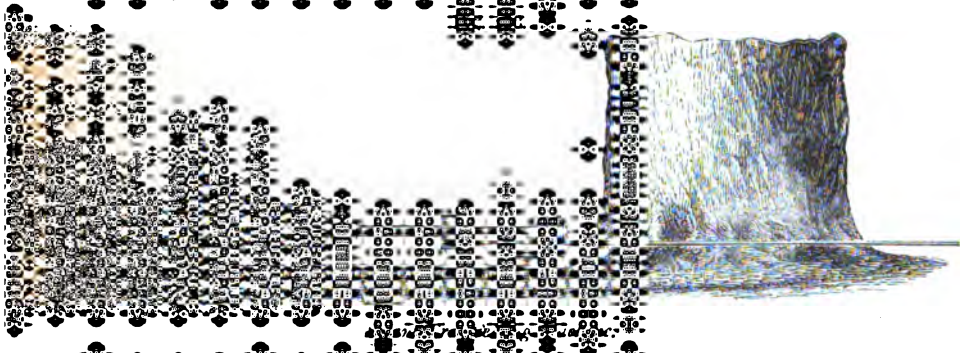
in charge of a junior

work in April 1883, so
The operations were
machine could call any-
of serious accidents to
returns as the "Steam
ordinary manner.
t that the experiment
e year, when water is
h pressure of steam is
extremely hard class of



se two latter considera-
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gyi sawmill in Burma,
arge logs of tough, hard
gths.

The Transport of Timber.

I. **Timber Transport by Land.**—Nothing facilitates forest operations so much as judiciously laid out roads, for they invariably add a large percentage to the value of the produce as compared with that from woods whence the extraction of the timber is difficult and costly.

It is keeping well within limits to assert that the produce of forests, extending to some hundreds of acres, throughout which there is no well-laid-out system of roads for the convenient removal of timber, is usually at least 20 per cent. lower in value than that of woods of the same extent, and grown under similar circumstances as to soil, situation, and nature of the crop, but in which there are good roads conveniently laid off. This is a fact which must appeal even to the inexperienced; for the removal of produce from woods in which there are no proper and convenient roads is such an inconvenience, and such a solid depreciation of its value, as to prevent many buyers from purchasing at all. It may consequently even compel the proprietor to accept almost whatever price is offered for it, even although this be far below its true market value.

The great loss often sustained by landowners owing to the want of roads in their plantations condemns the narrow policy of planting any enclosure of considerable extent without laying out a well-projected network of roads within it.

It is by no means necessary, and it is certainly not to be advocated from a financial point of view, that any considerable initial expenditure should be incurred. It is amply sufficient if the roadways or green lanes be aligned at the time of forming the plantations; and later on such preparation as may ultimately be required in the way of levelling, metalling, bridging, &c., can be carried out at the most opportune season before the roads will be required for active traffic. Except in the case of windfalls and damage from snow or ice, insects, fire, &c., these matters can always be foretold in properly managed woods.

When few or no roads existed in Lord Seafield's extensive woodlands, no timber merchant of any standing would make purchases there. But since roads were made so as completely to open up the forests from all points, there has been no difficulty in getting purchasers of the best class to come and settle in the district, where a large business in timber is now carried on.

The utility and advantages of roads in forests should on no account be lost sight of by any proprietor who wishes to make the most of the resources of his estate, as otherwise at least 25 per cent. of the value of the produce is lost.

The Network of Roads.—In all plantations of any considerable

extent, it is absolutely necessary to have roadways in the form of vacant tracts left unplanted. In laying these off in a new plantation, care should be taken to see that no part of the wood is above 150, or at most 200 yards distant from some one of such roads. The necessity of this precaution will appear evident when it is taken into consideration that the trees will have all first to be conveyed from the interior to these roadways before they can be made over to the purchaser for removal.

The roads in a plantation need not be made more than 18 ft. wide, if they are intended to be broad enough to allow two carts to pass one another with freedom when laden with wood.

This, however, is not absolutely necessary. It will be cheaper merely to arrange for halting stations within easy sight of each other, in all localities where the transport is not likely to be great at any given time.

When the roads are marked off before the woods are formed, they ought to be divided from the rest of the ground by a drain 24 in. deep, running along each side of them throughout their whole extent. Drains of more than this depth are often found dangerous to horses when getting into them with laden carts; and in order to obviate any risk of this kind, the sides next the roads should be formed with an easy slope of about 35°, thus making the inner sides of the drains form, as it were, the outsides of the roads. These are meant not only to keep the roads in a dry, firm state, but to give them an appearance distinct from the rest of the plantation; for, from being thus sloped into the drain on each side, they are not apt to be damaged by passing carts. But, in order that they may the better answer the ends in view, all sudden rises and hollows should be made even by taking from the one and adding to the other; and where any very soft parts may come into the line, these should be made dry by a stone-built culvert passing across and under the road, so as to connect the drains on each side of it. Where the roadways pass along the sides of a sloping hill, they should be levelled by cutting into the slope on the upper half, and adding the material removed to the lower side. And of course the line must be made smooth by the removal of all large stones.

If there be any particularly romantic-looking spot within the bounds of the plantation, the road should be made to take a turn in that direction. Or if there be any particular height from which a distinct view of the surrounding country may be had, the road should be made to pass by it, so that a narrow footpath may conveniently lead up to it. In making roads through woods, as well as in making walks through pleasure-grounds, good taste and ornament should be kept in view, where this does not lead to unnecessary outlay on a large scale.

In plantations of a more arboricultural and less strictly sylvicultural nature, it is well to have Holly-trees planted along the sides of the roads, as also Privets, Rhododendrons, Portugal Laurels, Laburnums, and Bays, all of which thrive well although a little shaded by trees; for, in the winter season particularly, the evergreens produce a fine effect in contrast with the leafless broad-leaved species of trees. Such slight ornamental points with regard to forest scenery are often by far too little attended to. Our woods might be made even more interesting in the winter season than the best-kept gardens were this object steadily kept in view; and much might be done at a comparatively trifling outlay to improve the natural beauties of the woodlands.

German Methods of Timber Transport by Land.—The network of roadways in extensive forests in Germany consists of **main-roads**, **side-roads**, and **feeders**.

The **main-roads** usually traverse the heart of the woods, and form the main thoroughfares along which the traffic is conducted. They are generally metalled. And when they can at the same time be used as public roads for connecting villages or as highways, they are macadamised and carefully prepared as chaussées. These main-roads have seldom, in the latter case, a higher gradient than 5 per cent.; but where they are to be used for timber-traffic only, and not as public highways, the gradient has often to be fixed at 7 or 8 per cent. Their breadth is dependent on the amount of traffic anticipated upon them, and is usually from 18 to 20 ft., as the actual width of an ordinary timber-cart is about 8 to 8½ ft. Wherever practicable, these main-roads should lead to some convenient depôt, whence further transport —by road, rail, or water—is easy.

The **side-roads** are formed in direct communication with the main-roads, and branch off from these into the inner parts of the forest. As they are intended for permanent use, they are projected in such a manner that they can be utilised continuously for the various falls in any given period of time which forms the unit of management (*i.e.*, usually twenty years), through being connected with the different annual falls by means of the feeder-paths. This class of roads may have a gradient up to 10 per cent., or even higher if they are to be utilised as timber-slides or sledging-paths. They vary in breadth from 8½ to 15 ft. In the former case passing-stages are requisite to permit two carts to pass each other, and in the latter there is plenty of room for loaded sledges to pass each other without inconvenience. It is not always necessary that these side-roads should be metalled; and, even if the conveyance of the timber from the forest is to be performed only on axle, any necessary preparation of the surface for traffic, such as macadamising with whatever metal can be obtained in the immediate vicinity, may easily be arranged for previous to the particular roads being brought into use.

The **feeders** are more or less of a temporary nature, *i.e.*, they are not intended to be used so continuously or to such an extent as the side-roads; hence metalling of any description is not requisite. When intended for use as **dragging-paths**, they only require to be about 3½ to 5 ft. broad; but when projected as **sledging-tracks**, they should have a breadth of 7½ to 10 ft. In dragging-paths the gradient may vary from 6 or 8 per cent. up to 18 or 20 per cent. according to the nature of the locality; whilst for sledging-

tracks the normal gradient lies between 12 to 15 per cent. Where several feeders join together before reaching the side-road, they are made somewhat broader if sledges are there likely to pass and repass frequently; whilst it is also well to try and confine the gradient at such short stretches to 8 or 12 per cent.

For **timber-slides** somewhat higher gradients are permissible, and even requisite; hence they vary from about 9 to 12 per cent. on the main-tracks up to 15 or 18 per cent. on the feeders. A continuous, and so far as possible an equable, gradient is more desirable for timber-slides and for sledging-tracks than for dragging-paths or cart-roads; for in the latter case, indeed, level stances and changes of gradient are less tiring to cart-horses than a continuous slope which necessitates the same set of muscles also being called into play.

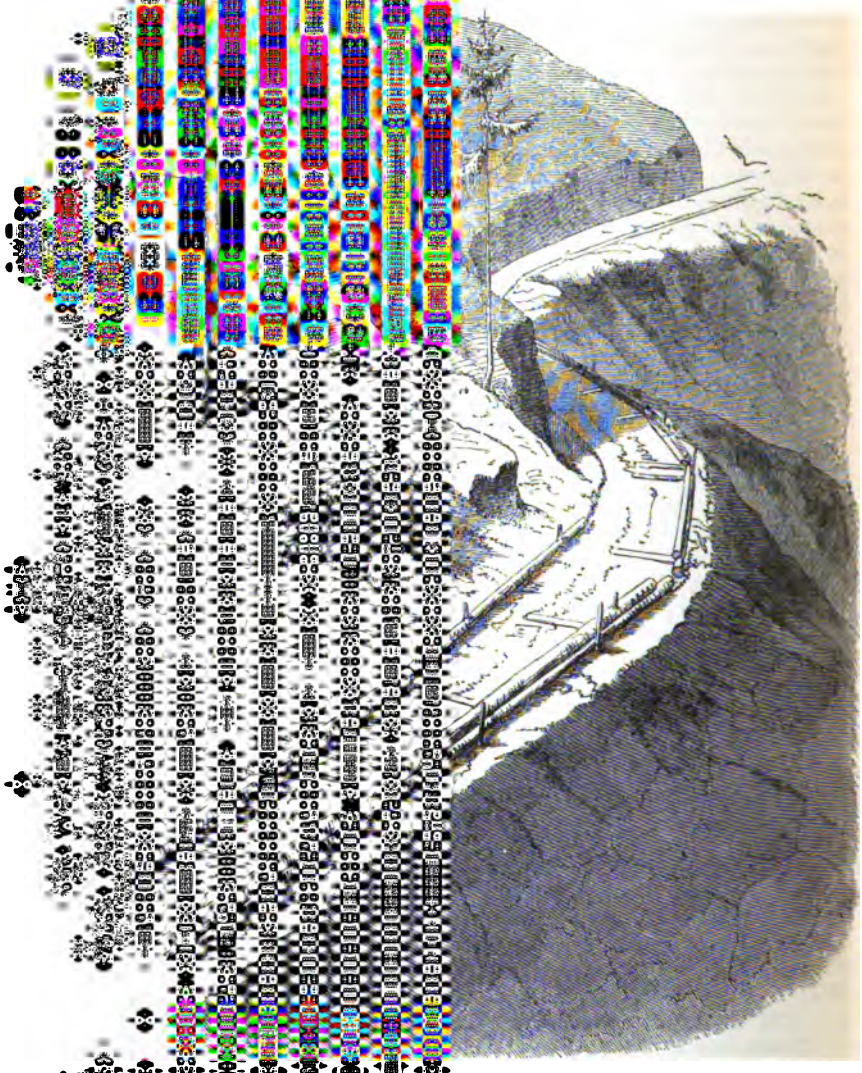
The complete road-system in an extensive woodland area should thus in its ramification somewhat resemble a tree. The main-road is like the stem or trunk, the side-roads are like the branches, and the feeders like the branchlets and twigs; whilst the breadth and the outlay incurred on the various parts should, so far as the circumstances of contour, nature of soil, &c., permit this, be more or less proportionate to the amount of traffic to be provided for, and to the amount of benefit to be consequently derived by the owner of the woods. In practice it will often be found impossible always to have a convenient gradient without incurring considerable expense, and in many cases a slight counter-gradient may often have to be included.

Carting Timber.—So far as the extraction of timber on carts or tumbrels is concerned, we have nothing to learn from the Continent of Europe. For the conveyance of very heavy logs on metalled roads, the English timber-cart is just as effective as any such machine could well be. It consists of four high and broad-tired wheels, the latter pair of which is adjustable to any given length desired, by means of a long pole or beam forming the body of the tumbrel. The front pair of wheels is brought into proper position over the lower end of the log as it lies on the road, and is lashed by chains to the hook on the thick lower end of the beam, which is raised perpendicularly aloft at the time. On bringing down the upper end of the beam and securing it to the axle of the hind pair of wheels, the strong leverage thus brought into play lifts the front part of the log clear up from the ground, and when the hind end of it is also raised by means of jacks or levers, and then securely fastened to the beam, the whole log swings clear of the ground and is ready for transport.

Sledging Timber.—This is a branch of forestry in which we are very far behind all the Continental nations,—a remark which also applies to the excellent method of extraction by means of **Timber-Slides**. Sledging operations may be conducted either by workmen alone, or also by means of horse-power. In the former case the term **sledding** may be applied, owing to sleds or small sledges being employed, whilst **sledging** may be more fitly used to denote the dragging of large sledges by horses or oxen.

There are various kinds of sleds and sledges, but they have all the same leading characteristics, consisting of (1) two **runners** or long horizontal pieces of wood, often shod with iron, which in the case of hand-sleds run up into bent points in front, that are grasped firmly by the man dragging the sled; (2) **cross-pieces** binding the runners, and serving as benches upon which to rest the timber; and (3) a **skid** or **drag** to regulate the speed. Hand-sleds are only applicable for the conveyance of comparatively light loads of wood, like firewood billets, light pit-props,

[illegible] into comparatively short lengths. [illegible], a load consists of from 55 to 70 [illegible] and a sledder working on a sledding [illegible] able gradient, can convey from about [illegible] 289.



[illegible] which may also be used as a Sledging-Track.

[illegible] from to a distance of $1\frac{4}{5}$ miles (3 kilo- [illegible] for the half of that distance; but either [illegible] such good results being obtainable. [illegible] ed by horses or oxen, are altogether of [illegible] transport. They consist of a front

sledge and a hind sled, in order to keep the ends of the logs from trailing along the ground and cutting up the earthwork. In some parts of the Black Forest large single sledges are often loaded with from 1,050 to 1,100 cubic ft. of Spruce or Silver Fir wood cut up into fuel billet lengths.

Sledding and sledging operations take place for the most part only while the ground is covered with snow, so that it is a method that can only be applicable to localities having severer winters than are usual throughout the greater part of Britain. Such operations can, however, easily be arranged for during the summer months through special preparation of the tracks (Fig. 289), by means of laying round poles on the ground, or split poles with the smooth side uppermost, so as to minimise the friction. These have to be fenced in with flange-like side-poles, in order to keep the sleds or sledges from gliding off the track. They are, in fact, just like rude railway tracks in appearance, but the sleepers are smooth and round on the top so as to offer a minimum of friction, whilst the sleds run over these horizontal bars in place of along the outer line of parallel poles. These sleeper-pieces must not be farther apart than will admit of the sled or sledge always resting on two, *i.e.*, will prevent any portion of the sledge touching the ground. According to Gayer (*ibid.*), in the construction of such summer-sledging tracks, with Silver Fir and Beech, at Hochwald, near Barr, the preparation of the track cost 43s. for every 337 yards over a total distance of ramifications amounting to 12½ miles; and the sledding track lasted ten years. Where dragging from the interior of the wood to the nearest roadway has to take place by means of horse-power, it may be calculated that one horse will be required for every 7 to 9 cwt. of dead weight of the timber; but, of course, much depends on the nature of the soil at the time of dragging.

Timber-Slides.—There are few branches of utilisation of forest produce which offers so wide a field for improvement as this particular method of extraction,—and more especially if the timber-slides can be made to terminate at any river or good waterway, that can be utilised as a floating channel for the conveyance of the timber to any favourable mart, or to large sawyards, whence transport of the converted material is favourable by road, rail, river, or sea. This is a method of transport widely and cheaply practised throughout all the mountainous tracts of Central Europe.

1. **Wooden Timber-Slides.**—There are different forms of timber-slides; but the leading principle is, of course, that a good bed should be prepared, down which the timber can glide with a minimum of friction, whilst side-pieces protect the logs or fuel billets from springing out of the slide. Wooden timber-slides are constructed of 6 or 8 poles of from 4 in. to 1 ft. in diameter; the lowest two of these form the base of the sliding-trough, which usually varies in total breadth from about 2¾ to 5 ft. The slides which are intended for the conveyance of large logs of timber, must of course be constructed more solidly than those required only for fuel billets. That represented in Fig. 290 is a long timber-slide in the Triftenthal Forest in North Tyrol.

The gradient is a very important matter with regard to the construction of timber-slides; for, whilst too slight an inclination makes them practically useless, too high a gradient is apt to induce such a velocity in the shooting timber as to cause it to spring out of the trough. But the permissible or advantageous gradients vary between wide limits, according to the circumstances of each case.

Thus, when dry slides are to be operated on, a gradient of 20 to 35, or even up to 40 per cent. is not excessive for fuel billets and small wood; whilst for heavy logs of long timber a range of from 15 to 20 per cent. is

slide is to be operated upon during are from 6 to 12 per cent. for small 6 per cent. for large timber. And in the damp climate of the Highlands ucted during wet weather as a rule, a two extremes for summer and winter iew. Wherever in any given parts of

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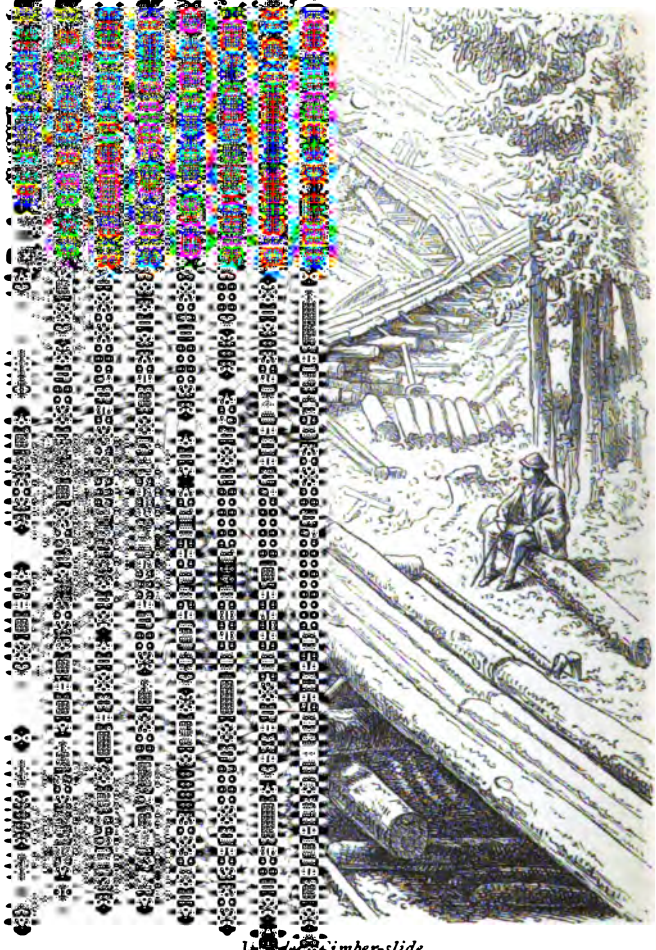

imber-slide.

ble, it should be succeeded by a short in order to check any tendency to the e timber. A check may also be given s represented in Fig. 291. This con- logs have to pass on their downward ising tends to lessen the velocity that nother method is to form checks by

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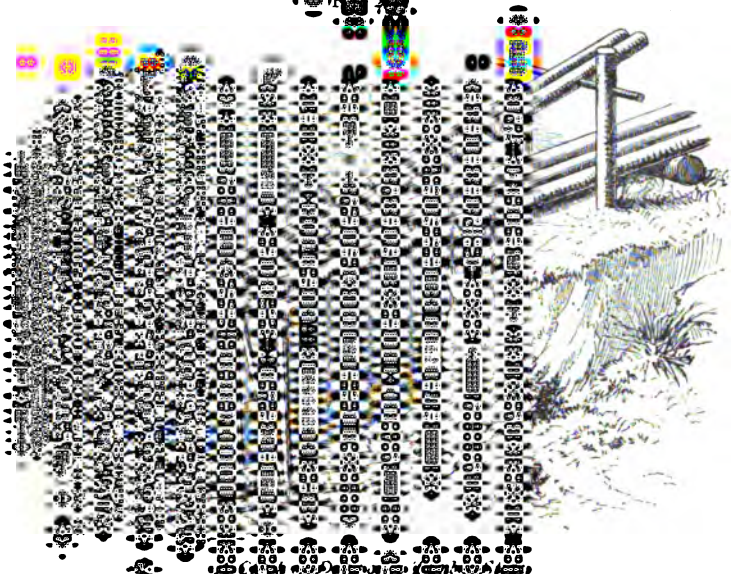

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localities where dragging-

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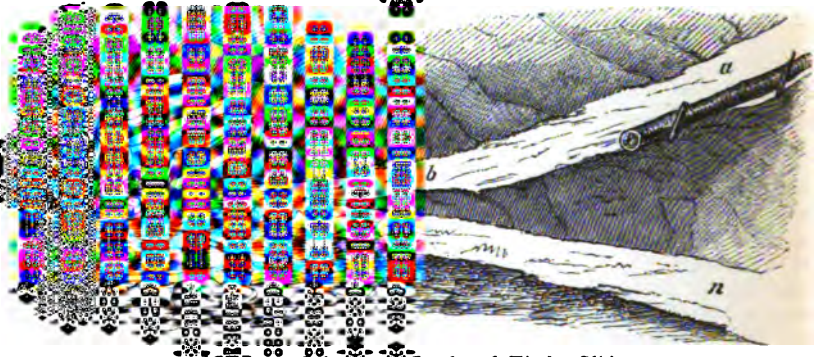

Earthwork Timber-Slide.

[illegible] not likely to run out of the track on [illegible] te except on the lower side; but, other- [illegible] ng both sides of the slide or shoot. [illegible] uire to be conducted with something [illegible] isation in order to prevent accidents. Before timber is launched at the upper end, a bugle or horn signal is given, which is repeated down the line by men stationed at different points, and then passed up again, to ensure that the slide is clear, before the log leaves the top. Its arrival at the depôt below is indicated by another preconcerted signal being passed up the line; and so on with each log.

When all the timber from [illegible] used in the fencing-in of the slide can [illegible] top, if the slide be no longer required.

[illegible] ut the Rocky Mountain tracts, enor- [illegible] ved for immense distances in flumes [illegible] tion of the flume is exhibited in Fig. [illegible] gh formed of side-boards *mm*, and is [illegible] of any rivulet or water-channel into [illegible] timber placed or launched therein. [illegible] ater-troughs or floating-channels on a [illegible] be such a very economical and prac-

tical method as to be well worthy of recommendation for adoption in the Highlands of Scotland; hence a detailed description may prove of service to those personally interested in the matter of timber transport.

The flume consists of strong boards 32 in. broad and 16 ft. long, nailed together so as to form a V-shaped channel, occurring one after the other for miles sometimes; it was first developed and used in Washington. Endeavours had often been made to transport timber in troughs; but the latter had always been made rectangular, and this occasioned their non-success.

Semler gives the following account of the construction and working of a flume:[1]—

"The formation of a flume is not as simple as one might suppose. It demands the whole art of the engineer, especially on broken hilly ground; and many assert that a railway is easier to project and construct than a flume. First of all, attention must be paid to the essential supply of water, for which a reservoir must be formed. Simultaneously therewith the laying of the flume is commenced, and of course it must have no sharp bends or short curves. Here the bed must be worked out of the rock, there the framework has to stretch across gullies from 160 to 240 ft. deep, above which it is supported by a strong wooden frame-work resting firmly below and connected with the sides of the gully by stout iron rods in order to protect it against the violent winds that, sweeping down the small valleys, would otherwise soon overthrow it. It need hardly be mentioned that when a flume has to cross many gullies it becomes rather costly; the construction amounts to as much as £960 to £2000 per mile, and even more when there are special difficulties to be overcome.

"When the flume is ready, and the requisite head of water has been provided, the transport of the logs begins to the starting-places, whence, without any connection with each other, they are borne rapidly down to the mills, 20, 30, or 40 miles distant. With a fall of 1 in 192 (or little over ½ per cent.) a speed of 2 to 3 miles an hour is attained, whilst with double that fall the speed becomes trebled, and with a gradient of 10 to 12 in 192 (*i.e.*, 5 to 6 per cent.) the timber acquires a velocity of about 20 miles an hour and more. From the highest starting-place in the mountains down to Sacramento is a distance of over 31 miles, and this is covered in 3½ hours. To Chico, a distance of 42½ miles, the transport is still more rapid, as it takes place in less than four hours. The Chico flume is nearly 47 miles long. The last logs are started at three o'clock in the afternoon, and reach Chico about half-past six in the evening. Formerly, when the timber had to be brought down by waggon, 1000 metres (36,000 cubic feet) cost £7 for transport, whilst by flume it may be estimated as under 10s. The above-mentioned main channel of the flume can bring down 30,000 metres (1,080,000 cubic ft.) per diem, and the whole flume system can bring down three times that quantity.

"Along the whole distance, from the highest starting-point down to its mouth, men stand at stated intervals to superintend the flume and see that no obstruction takes place —a matter of necessity at places where side-branches join the main flume. For this purpose a board gangway is ranged alongside the flume in order to permit of the men moving quickly from point to point.

"The only drawback to this method—and it is one that can hardly be removed—is the want of water that occurs almost every summer. Wherever practicable, this is modified by the formation of large reservoirs that can fill themselves when the snow melts, and by husbanding the water supply and only opening the lock-gates when the starting of logs can take place continuously; during other times the flume is kept dry. More frequently, however, the work of felling takes place throughout the summer, the timber being extracted to the camp-depôts along the flume, whilst the transport is carried on during the rainy season. . . . The whole flume-net has a total length of nearly 125 miles, and it is continually being extended."

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[1] *Tropische und nordamerikanische Waldwirthschaft und Holzkunde*, Berlin, 1888, p. 334.

At Chico the flume ends in a lake into which the logs plunge before being removed to the permanent depôt near the sawmills. The Sierra Flume and Lumber Company, to whom the concern belongs, employ 500 hands in their mills and in the forests, and pay out £100,000 annually in wages; in addition to that they keep 500 oxen, 100 horses and mules, and 61 timber-waggons at work, mostly in the mountain-forests. Their mills have an annual output of 16 million metres of boards (575 millions of cubic ft.). which represents exactly half of the annual out-turn from the State of Oregon.

The Rentage or Revenue derivable from Woodlands unmistakably depends to a much greater extent on the application of convenient methods of extraction and transport, that will save the outlay in time and labour, than on the intensivity with regard to methods of culture, however important these may be (and undoubtedly are), having regard to the rentability of the forests a hundred years hence, when the plantations of the last quarter of a century approach maturity.

There are many localities with good growth of useful species of trees from which the timber cannot be got out, *i.e.*, to which the existing methods of extraction cannot be applied so as to leave a margin of profit on the transaction. Thus, for example, as larger falls take place on a given area on the Pacific coasts of the United States of America than in the Eastern States, narrow-gauge railways are formed where water transport cannot be made available from and to the "lumber-camps." The lines are firmly laid, though not carefully levelled, as they are intended to last for years, being extended annually and not moved from place to place. The locomotive (Baldwin Locomotive Works, Philadelphia) has a patent crane, which can load and unload logs of 20 to 30 tons weight (redwood logs of 16 ft. in diameter), the locomotive being kept in position meanwhile by a strong steam-brake. This patent steam-crane, worked by a donkey-engine, can also be removed and employed instead of oxen for bringing logs. It is fixed on a sled, and works itself forward to the place required if the hawser be fixed to trees ahead; and when it reaches the place of working it must be firmly moored to trees near at hand. It can be used in extracting logs from coombs where dragging animals cannot possibly work.

Forest Railways.—Semler (*op. cit.*, p. 301) recommends as cheapest and most practical the "**pole-railroads**" of North America. In 1886 there were 383 such forest-railways running over 2287½ miles, on which 428 engines and 5182 tender-waggons were employed. Instead of having rails, poles are used, like telegraph poles, having a diameter of not less than 9·2 in. at the thin end. The thick end of each pole is hollowed out slightly with the axe so as to permit of the thin end of the next pole fitting into it, after which it should be pared down towards the level of the latter.

The peculiarity of the engines is that the wheels are driven by chains, and that each wheel is moved independently of the other, so that if any one chain should break or get into disorder, the movement of the whole is not materially affected. They have a dragging power of six waggons laden with 3000 metres (108,000 cubic ft.) of boards, and with a gradient of 4 per cent. can proceed at the rate of five miles per hour. Some of these railways are worked on ground having a gradient of 13 per cent., the engine being placed in the middle of the six trucks, and when the train arrives at the steep part it is taken up in two sections.

The poles are simply laid on the ground and firmly packed with earth to keep them in place when the train passes over. Wherever necessary, of

course, some rough levelling has to be undertaken on uneven ground; and in any case the laying of the track is most advantageously carried out during wet weather.

No sleepers are necessary, as the wheels of the engine and the trucks are hollow, have deep flanges, and have a certain amount of free play on the axle-tree which serves to keep the ends of the poles in position whilst the train is passing along. After a few trips there is little danger of the poles shifting.

When curves are to be formed, then shorter poles are used, being laid down in the same manner. Wherever side-branches join the main lines, the junction must always be made in a curve.

One workman can maintain nearly two miles of track in order.

The cost of formation varies under ordinary circumstances from £10 to £20 per kilometre (£16 to £32 per mile), according to the nature of the ground and the rate paid for labour. In rugged mountainous tracts the cost may even amount to as much as £30 to £35 per kilometre (£48 to £56 a mile); but it must be recollected that in North America labour is exceedingly expensive.

The locomotive costs 3000 dollars (£630), and the trucks 125 dollars (£26, 5s.) each; they are obtainable from Messrs Tanner & Delaney, engineers, Richmond, Virginia.

In some localities the dragging power is by animals (horses, ponies, cattle); but, even despite the saving in capital outlay, this method is dearer in the long-run, and involves a considerable loss of time.

These pole-railroads are mostly to be found in use to the east of the Rocky Mountains. Along with them steam-loading machinery is generally in use, called "log-skidding and loading machinery" (Butters & Peters, Ludington, Michigan).

II. **Timber Transport by Water.**—The **floating of timber**, either by means of **drifting** in single logs or of **rafting**, when from a few logs up to several hundreds are lashed together so as to form one continuous raft, is a method of transport which, with a bulky raw-product like timber, must always come far cheaper than any other manner of conveyance whenever floating-channels can be rendered available, so as to lead to any great central mart or emporium for conversion.

All our coniferous woods and the great majority of the broad-leaved species are floatable without any seasoning in order to reduce their specific gravity, as has been pointed out with regard to the various kinds of different trees in chapters ii. and iii.

This method of transport is practised in the Strathspey district, for example; but its highest development has been attained in the mountainous tracts extending from the Black Forest eastwards throughout the Bavarian Alps into Austria. Large forest-engineering works are maintained for reservoirs to flood the channels when required; and costly dams, sluices, corrections of the channel-beds, and paving of the sole of the bed, have been undertaken on a large scale in order to permit of the extraction of the timber in the most effectual and ultimately the most economical manner.

Drifting operations may commence anywhere in the heart of the forest, simply by launching the logs into the bed of the floating-channel; but rafting operations can only be begun at some convenient depôt, such as may be formed at the junction of two streams, or at the termination of some main road or timber-slide, where large quantities of wood are collected for further transport either to market or to the place of conversion. Both drifting and floating operations are confined to localities in which there are good supplies of water.

Critique of the Various Methods of Timber Transport.—The loss of wood in **sledging** or in **conveyance by cart** is usually nominal, and these must therefore be considered the most economical methods so far as the full harvesting of the timber is alone concerned. The loss by transport of timber down **timber-slides** that are not interrupted by precipitous rocks is barely in excess of 1 per cent. in well-planned slides; but when interruptions of that nature cannot be avoided, the loss may amount to 15 or 20 per cent., especially if the precipitous places are in the lower half of the slide, where the velocity of the timber is naturally greater than higher up. **Drifting operations** cause a loss of from 2 to 15 per cent. of the wood originally launched; whereas the loss by **floating** is only nominal, unless the current is so swift as to cause the breaking up of a raft occasionally, and the carrying out of logs to sea. According to Gayer (*op. cit.*, p. 348), the calculations made for the Ramsau Forest in the eastern portion of the Bavarian Alps, where all the various methods of transport may be seen in operation, show that, under local difficulties far greater than would usually be presented in even the most mountainous and wildest tracts of Britain, the total loss of timber during transport amounts to about 6 per cent., of which 4 per cent. is incurred during **transport by land**, and 2 per cent. during **transport by water**. These results have, however, been improved by the continuous formation of good pathways suitable for sledging and timber-slide operations.

What the editor would specially recommend to the notice of Highland foresters is the formation of roadway timber-slides, in connection with rafting-channels, by means of which the logs can be conveyed to a good mart.

Bank Repairs to Streams.—Although not directly connected with Arboriculture in the proper sense of the term, yet the repairing of the banks of rivers, where they have been injured by floods, is a duty which generally falls to be performed by the forester.

The breaking down of the sides of a river generally takes place while it overflows its banks after a heavy fall of rain, and chiefly occurs where any considerable obstruction prevents the proper flow of the water, or where a sudden bend in the river causes the force of the current to undermine the bank, at the spot where the bend occurs. Damage to river-banks from obstructions and sudden bends is most to be feared where the river is running rapidly, and therefore where it has greater force to undermine and wash away the soil. All river-banks are more or less liable to fall away gradually in pieces, and especially where the subsoil is of a shifting gravelly nature; hence, where rivers run through an estate, the banks must be seen to and kept in proper condition.

One great cause of damage to river-banks is the too frequent neglect of keeping the bed of the river clear of all obstacles that can in any way hinder the free flow of the water, such as large roots, or even trees, and large stones. These should be removed as soon as practicable; for they are apt to cause damage by impeding the natural flow of the stream, and by forcing water against the banks which would otherwise flow on quite freely.

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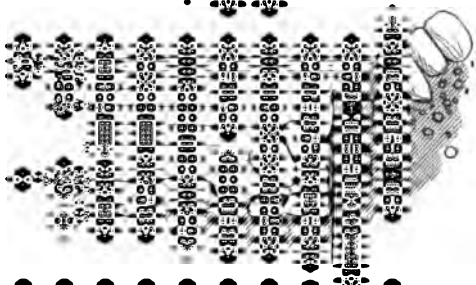

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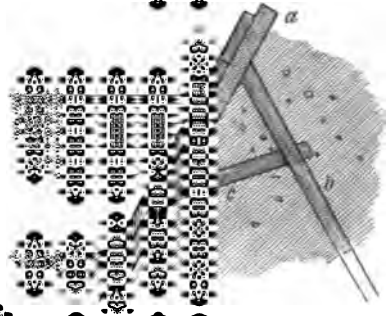

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floods.

on the banks of a river, it should

be at once attended to and made good; for if it be left unprotected, as is too often the case, the damaged part will gradually become larger, and therefore more difficult and expensive to repair.

Large trees should not be allowed to grow close on the sides of streams, as their roots form an obstacle to the free current of the water; hence eddies are formed, and the banks gradually become undermined and fall in.

Wherever the banks of a stream have a tendency to fall in, they should be planted with **Willows**, as the fibrous roots of this class of plants very soon occupy every portion of the soil, to a depth of from 3 to 4 ft., and preserve the banks of rivers from the scouring action of water. Willows planted in such a situation should not, however, be allowed to grow up as trees, but merely as Osiers; they should be cut over every season, in order to keep them down, and to prevent them forming any obstacle to the current of the water while the stream is in flood.

The Conversion of Timber.—On any property having a large extent of woods, it sometimes becomes necessary to have the means of converting timber either by water or by steam according to circumstances.

Where there is a large extent of woodland crops approaching maturity, and where in the neighbourhood of these there is a water-run of sufficient magnitude to propel sawing machinery, it will generally be found most economical and advisable to make use of this, as water-power is more simply and cheaply secured than steam-power.

Fixed sawing powers are, however, in many cases disadvantageous for the manufacture of timber, and this must always be the case where the several plantations on a property are each comparatively small; as, from the sawing power being stationary, no great supply of timber can be obtained for feeding it without more or less outlay in carriage. When considerable distances, therefore, intervene between the plantations, and where they are each comparatively small, it becomes desirable to use portable steam-machinery, so that at no great cost the sawing power may be moved from place to place near the timber, instead of the timber being conveyed to the sawmill.

Whether fixed water-power, fixed steam-power, or a portable steam-power should be used, will always depend upon the nature and character of the woodland crops, as well as upon their relative extent and position. Where the supply of wood to be converted is likely to be maintained for a considerable number of years, where there is a plentiful supply of water, and where the carriage is not likely to exceed a distance greater than from 1½ to 2 miles at farthest, it is better to have a fixed sawmill than to use portable power; because,

generally speaking, power can be applied from a fixed engine much cheaper than from a portable one, and the former is usually more easily maintained than the latter, besides being less likely to get out of order.

Where the plantations or woods are each comparatively small, and where they are far apart, it will be found advantageous to use locomotive steam-power for conversion; for this can be removed from one locality to another as occasion demands.

The advantages of proper sawing powers in cases where large woods have to be cut down are immense; for, wherever these are not provided, the price realised is apt to be small. Where there are large tracts of woodland without sawing powers near at hand for conversion, the principal obstacles to the ready sale of the timber are the great amount of outlay necessarily incurred by the purchaser for its removal in the original round state, and at the same time his incapacity to get rid of the great bulk of what is practically to him useless wood, in the form of the outer slabs. But, where the purchaser may have the opportunity of converting timber near the spot where the wood is cut, this obstacle is done away with, and he can, with comparatively little trouble, relieve himself of all the valueless portion of his purchase, by at once converting it into a proper and marketable state, whilst reducing the costs of carriage to a minimum.

A very great advantage gained by the proper and judicious application either of steam or of water power to the conversion of timber, is that of working up even the refuse of the trees, the slabs and top-ends, into useful and saleable material, such as staves and small boards for packing-boxes.

The cost of sawing machinery varies according to its capacity for doing work. Generally speaking, however, a good fixed sawmill, propelled by water, and of twenty-horse power, may be erected for about £500. A fixed steam-power, of similar capabilities, will cost from £600 to £700, or even more, according to circumstances; while a good portable steam-engine of similar power, with mill-sheds and machinery complete, may cost from £800 to £1500, according to the quality of the materials used in constructing it, and according to its capacity and convenience.

It would be superfluous in a work of this kind to give plans and specifications for sawmills and machinery suitable for the conversion of timber into the various forms in which it is used, seeing that full information can be obtained from the catalogues issued by firms of good standing, such as Messrs Robey & Co., Globe Works, Lincoln; Messrs A. Ransome & Co., Stanley Works, Chelsea, and others.

The attention of landed proprietors and foresters concerning wood-working machinery may here very appropriately be called to the Timber

Trade Hand-Book, No. 3—*How to Select Wood-working Machinery*, by J. S. Ransome, A.M.I.C.E., published by Messrs William Rider & Son, 14 Bartholomew Close, London, E.C.

Should Proprietors Convert their own Timber?—This is a question that may often present itself for some practical sort of answer.

In many cases proprietors who convert their own timber for sale realise a greater amount from it than they could by selling it in the round to timber merchants; but in the vast majority of cases the proprietors lose heavily by converting on their own account. Hence, as a rule, it is best to sell the wood in the round to timber merchants, and to let the latter convert it for themselves.

This will appear evident when it is pointed out that any proprietor, in converting his own timber, must at all times be subject to the guidance of some servant who has the management of such an establishment; for he cannot do the work or make bargains with regard to it himself. Hence it follows that if a proprietor is so fortunate as to secure the services of a really judicious and skilful man to superintend the conversion of his logs, he may be able to realise the highest possible return from it; but, on the other hand, if he should be unfortunate enough to put the establishment into the hands of a less qualified man, he is almost sure to lose by the transaction.

Cases have sometimes come under the author's notice in which large quantities of comparatively young trees had been injudiciously cut out from young and growing plantations, for the purpose of supplying extensive orders that had been received at the saw-mills, several of which were established on the property and kept in the proprietor's own hands. For several years previously the forester had the management of the mills, made all bargains with respect to sales of the timber converted, and directed the cutting of the trees in the woods for conveyance to the sawmill.

When the state of this establishment was examined into, it was found that a large amount of expenditure had been incurred every year in the carriage of the timber from the different woods to the sawmills, and that all the work had been done by day-labour; the results proved that for several thousands of acres under valuable woods, only about £1000 per annum of clear income had been realised.

As the results of this particular establishment are quite in keeping with those of many others of the same sort, it is only right to show how such mills are generally conducted, and especially how it was that the one referred to did not produce more satisfactory returns.

Inquiry showed that the horses kept for the conveyance of the trees from the woods to the mills were the proprietor's own, and were maintained at considerable outlay; that they brought but light loads

from the woods, and seldom worked when the weather was wet, or when the men in charge of them could not work comfortably. The men engaged in felling the trees in the woods were paid by the day; a certain number of them were kept regularly employed in this way, and they assisted in loading the carts as they arrived from the mills. In the mills it was found that the sawyers were also employed by the day, that they stopped the work of sawing always when the carts with the wood arrived, in order to assist in unloading them, and that every man took the work quietly and easily as it best suited his comfort. Such a state of things does not obtain in sawmills which are kept by timber merchants who buy timber from landed proprietors, and convert it upon their own account; for with such men the work is conducted on the strictest business principles, and in the full knowledge that money is time.

Timber merchants usually keep few or no horses of their own; they contract for the conveyance of all timber from the woods to the mill, at a certain rate either per tree, per ton, or per cubic foot. They also contract for the felling and trimming of all the trees in the woods at a rate per tree or per foot, and have nothing to do with the handling of the timber or the loading of it on the carts. In the sawmill every individual is found striving to do his utmost in his own branch of the work, as all the conversion of the timber has usually been contracted for at a fixed price per 1000 superficial ft., according to the width and thickness of the boards, or at so much per sleeper, &c., and every branch of the business is conducted by piecework in this way.

The difference in the modes of working, as explained in the two preceding paragraphs, at once shows why the sawmill establishment of the landed proprietor was so expensive, and why he did not realise so much income from it as he should have done. It was because his servants made the whole work subservient to their own convenience rather than to his interest. And yet the men did not realise nearly such a high rate of wages as those employed by the wood-merchant; hence these latter were really much better off than the former. The proprietor's men had only 2s. per day, while the wood-merchant's contract hands made from 3s. to 3s. 6d. each. In short, the timber-merchant's establishment was conducted upon a sound and economical principle, while that of the proprietor was not; hence the former made a considerable profit from converting the timber, even after paying a high price for it, whereas the latter did not realise more than the half of the real value of his wood. Unless, therefore, a sawmill be properly conducted, it is more likely to become a loss to its proprietor than a gain; and unless proprietors can secure the services of really experienced, judicious, and efficient men for the conversion of

their timber, it will be far better to sell the trees standing,—or else simply to fell and log them, and to sell the logs in the round.

A proprietor having sawmills upon his estate should let them at a certain annual rent to such timber-merchants as contract to purchase the round timber from him at specified terms. This mode of going to work will probably in most cases be found that which proves the most advantageous.

It is often of considerable advantage to a proprietor to have a small sawmill for converting such timber as may be required for estate purposes; but as this is merely for home convenience, and is not understood under conversion for sale, the result is, in that case, more likely to be beneficial when the work is made over to the superintendence of a judicious forester.

But, even although the results with regard to the conversion of timber were to be generally profitable to the proprietor, there may occasionally be great temptations to treat the woods in the interests of the sawmill, in place of subordinating the work of conversion entirely to the requirements of the woods and their attainment of financial maturity. When an order comes in for a special class of wood, the forester is sent out to procure it from a certain plantation, from which it is taken without due regard to the future welfare of the crop. It therefore follows that all crops thus dealt with may be injured to a very considerable extent, and may never afterwards attain the same ultimate value that they probably would have attained had they not been interfered with, merely in order to comply with orders. This is so often done, that a protest must be made against such a mode of dealing with woods and plantations. Where sawmills are kept by the proprietor for the conversion of timber on his own account, the forester is sometimes even sent out to cut trees of a certain size from a plantation that may have been thinned only one year previously; these stems subsequently cut out could not be properly spared from the crop, which ought certainly to have stood for at least other two or three years before being again thinned. Such examples belong to the worst possible class of mismanagement. Still it is the method sometimes adopted where sawmills are worked directly by proprietors; and it is one of the real causes of the wretched state in which the woods are to be found on many properties throughout Britain.

Few proprietors who keep sawmill establishments on their estates are aware of the damage that is done to their plantations by foresters who take in orders, and supply them from such of the woods as will produce the class of trees, often immature, wanted at the time. The orders are generally accepted without much previous consideration on the part of the forester as to whether the trees are to be had without

doing damage to the growing crops or not. But, once undertaken, the order must be executed; and for this the trees must be cut from some one or other of the plantations, whether they can be judiciously spared or not. The result generally is that the woods are searched all over for certain trees, the removal of which is only too often a greater loss to the proprietor than can be made good by any monetary return obtainable for them in their immature condition.

The Weight of Timber.—The comparative weight of the different sorts of timber is a matter that is often overlooked in making calculations with reference to the carriage of wood.

The following tables, showing (1) the weight of Spruce, Scots Pine, and Larch timber, and (2) the weight of the wood of broad-leaved species of trees, were prepared by Mr. Rait, forester at Castle Forbes, from investigations made on home-grown timber.

The first of these tables should be compared with the table of Specific Gravities of Coniferous Wood of Continental growth, previously given in vol. i. chap. iii. p. 331.

By means of this tabular statement, the information given in a convenient form includes—

1. The weight per cubic ft., and the number of cubic ft. to a ton, in the rough or unconverted state.
2. The weight per cubic ft., and the number of feet to a ton weight, both in the green and dry states, of the same sorts of wood, but not converted.
3. The weight of the different kinds of timber with the bark on and with it off. This is of great advantage, as in the carriage of such unconverted timber it is always desirable to know the weight of it under both conditions.
4. The weight of timber in the converted state (this is given both in the green and the dry state) per cubic ft., and the number of cubic ft. to a ton, both in the green and dry state. These details are given with regard to boards and scantlings, as well as to the heartwood and sapwood of each sort respectively.

It may be interesting to call attention to some of the results of the experiments with reference to the weight of Spruce. As is shown in the first column, the age of the timber experimented on varied from 35 years to 90 years; while, in the third column, it is shown that barked logs of Spruce are practically of the same weight (69⅞ lb. per cubic ft.) from 35 to 50 years of age; but that when Spruce is so old as 90 years, it becomes reduced to 57 lb. per cubic ft. And passing on to the seventh column, it may be remarked that the number of cubic ft. to a ton of Spruce timber, without the bark, is as nearly

WEIGHT OF DIFFERENT KINDS OF TIMBER.—Synopsis of Experiments made with the view of finding the Weight of Spruce, Scots Pine, and Larch Timber, both in the Round and Converted, and both when Unseasoned and Seasoned.

Species of Timber.	Number of Years Planted.	In the Rough or Unconverted State.								When Converted.															
		Weight per Cubic Ft.				Number of Cubic Ft. to a Ton.				Inch Boards.				Scantlings.				Heartwood.				Sapwood.			
		By Rule 1.*		By Rule 2.†		By Rule 1.		By Rule 2.		Weight per Cubic Ft.		Number of Cubic Ft. to a Ton.		Weight per Cubic Ft.		Number of Cubic Ft. to a Ton.		Weight per Cubic Ft.		Number of Cubic Ft. to a Ton.		Weight per Cubic Ft.		Number of Cubic Ft. to a Ton.	
		Bark on.	Bark off.	Bark on.	Bark off.	Bark on.	Bark off.	Bark on.	Bark off.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.
		lb.	lb.	lb.	lb.					lb.	lb.			lb.	lb.			lb.	lb.			lb.	lb.		
Spruce . .	50	74¼	69⅞	58⅜	55	30¼	32	38½	40⅜	56½	26½	40	85	47-54	27½-28 5/16	41½-47⅞	79-82	31⅛-37½	24½-28⅜	59¼-70½	78-92	62 7/16-63	26-27	35¼-35⅞	83-86¼
Do. . .	90	64	57	50	44½	35	39½	44¾	50½	43⅜	31½	51⅛	71½	39¼	33½	56⅜	67⅜	32½	28½	69	79½	62 7/16	34⅞	35⅞	64¼
Do. . .	35	74½	69⅞	58¾	55¼	30¼	32 1/16	38⅛	40½	..	..	..	..	52⅜	27¾	42½	80¾	32	26⅞	70	83¾	61	28	36⅜	80
Scots Pine .	60	81½	75 7/16	63½	59	27⅝	29¾	35 1/16	38	..	..	..	..	58¼	30 7/16	38¼	73½	37	33½	60½	66⅜	63	29¼	35½	76½
Do. .	60	84½	78½	66	61¼	26½	28½	34¼	36⅜	60⅝	30½	36⅜	74	55⅝	28	40¼	80	..	..	..	..	..	..	..	..
Do. .	60	83¼	77⅜	65½	61½	27	29	34½	36⅜	59½	29½	37⅜	75¼	55⅜	30½	40¾	73½	..	..	..	..	..	..	..	..
Do. .	100	75½	69⅝	58⅜	54½	29¼	32½	37½	41½	54¼	32⅞	41½	68⅜	49	32½	45¾	69	..	..	..	..	..	..	..	..
Larch . .	60	70⅝	62¼½	55 5/32	48⅛⅛	31⅜	35⅜	40⅜	45⅜	..	..	..	..	43⅜	29¼⅜	51 5/16	75⅜	35	31½	64	71	48	32½	46⅜	69
Do. . .	60	77 19/32	69	61	54 1/16	28¾	32¼	36⅝	41⅞	54	39	41½	57⅜	46¼	34 13/16	48½	64½	..	..	..	..	..	..	..	..
Do. . .	60	68	61	53	47⅜	33	36⅜	42¼	47	44¾	28⅜	50	78⅛	39½	28¼	56⅜	79	..	..	..	..	..	..	..	..

RANGE OF AGE AND WEIGHT.

	Years.	lb.	lb.	lb.	lb.	Cubic Ft. to a Ton.	Cubic Ft. to a Ton.	Cubic Ft. to a Ton.	Cubic Ft. to a Ton.	lb.	lb.	Cubic Ft. to a Ton.	Cubic Ft. to a Ton.	lb.	lb.	Cubic Ft. to a Ton.	Cubic Ft. to a Ton.	lb.	lb.	Cubic Ft. to a Ton.	Cubic Ft. to a Ton.	lb.	lb.	Cubic Ft. to a Ton.	Cubic Ft. to a Ton.
Spruce . .	35-90	64-74½	57-69⅞	50-58¾	44½-55½	30¼-35	32-39½	38¼-44¼	40½-50¼	43¾-56½	26½-31½	40-51½	71½-85	39½-54	27½-33½	41½-56⅜	67¾-82	31⅛-37½	24½-28⅜	59¼-70½	78-92	61-63	26-34⅞	35¼-36⅜	64¼-86¼
Scots Pine .	60-100	75¼-84½	69⅝-78½	58⅜-66	54½-61½	26¼-29¾	28¼-32½	34½-37½	36⅜-41½	54¼-60⅝	29½-32⅞	36¼-41½	68⅞-75¼	49-58¼	28-32½	38½-45¾	69-80	37	33½	60½	66¾	63	29¼	35½	76½
Larch . .	60	68-77 19/32	61-69	53-61	47⅜-54 1/16	28¾-33	32½-36⅜	36⅜-42¼	41⅞-47	44¾-54	28⅜-39	41½-50	57⅞-78½	39½-46½	28¼-34 13/32	48¾-56⅜	64½-79	35	31½	64	71	48	32½	46⅜	69

* Rule 1 is the mode of measurement in common use; one-fourth of the girth squared and multiplied by the length.

† Rule 2 is the mode of measurement which would be nearly correct were trees perfectly cylindrical; one-fifth of the girth squared and multiplied by twice the length. This rule has been applied in order to ascertain how nearly it and the weight of the newly-sawn boards would approach each other.

as possible the same at 35 and at 50 years, being $32\frac{1}{16}$ and 32 respectively; while, when the timber arrives at 90 years of age, it is shown that $39\frac{1}{8}$ cubic ft. are required to make a ton weight. This is of importance to those who deal in such timber, as it gives evidence that mature crops of this wood will cost less for conveyance than where there is a larger proportion of young wood.

Again, compare the weight of the heart and sapwood of the Spruce. Passing along to the right-hand side of the table, it may be seen that 1 cubic ft. of the heartwood of Spruce in the dry state, and at 35 years of age, weighs $26\frac{3}{4}$ lb.; while at 50 years of age it varies from $24\frac{11}{32}$ to $28\frac{23}{32}$ lb.; and at 90 years of age it generally weighs $28\frac{1}{8}$ lb. On the other hand, 1 cubic ft. of the sapwood in the dry state, and at 35 years of age, weighs 28 lb.; at 50 years from 26 to 27 lb.; while at 90 years it weighs $34\frac{7}{8}$ lb.—thus showing that at all stages of the growth of the tree the sapwood is considerably heavier than the heartwood.

The results noted with reference to the weight of Scots Pine timber are taken from specimens between 60 and 100 years of age.

The experiments made with regard to the weight of the timber of the Larch are of a more limited character than those of either of the other two kinds, and are confined to trees of 60 years of age. Still, so far as they go, they are very useful. They show that the weight of a cubic foot of Larch timber, produced by a tree of 60 years of age, in the round state and with the bark off, varies from 61 to 69 lb., and that from $32\frac{1}{2}$ to $36\frac{2}{3}$ ft. are required to make a ton weight.

The table referring to the broad-leaved species of trees is as follows:—

TABLE SHOWING THE WEIGHT OF OAK, ASH, ELM, BEECH, BIRCH, PLANE, AND HORSE-CHESTNUT, both in the Round and Converted, and both when Unseasoned and Seasoned.

In the Round or Unconverted State.							When Converted.					
Species of Tree.	Years Planted.		Girth in Inches.	Comparative weight in Pounds of a Piece with and without Bark.	Weight per Cubic Foot in Pounds.	No. of Cubic Feet to a Ton.	Where cut from.	Dimensions of Sections.	Weight per Cubic Foot.		Cubic Feet to a Ton.	
									Green.	Dry.	Green.	Dry.
								ft. in. in.	lb.	lb.		
Oak . . .	100	Bark on	32½	35	90	24⅜	Heart of log	1 3 × 2	69	53¼	32½	42
		Bark off	30	31½	81	27⅛	Sapwood	1 3 × ¾	62¼	41	36	54⅝
Oak . . .	52	Bark on	27	24 25/32	93 9/32	24	Heart of log	1 3 × 2	73⅞	50⅜	30⅛	44⅛
		Bark off	24¾	22⅛	83¼	26 11/12	Outside	1 3 × 2	67⅛	48	33⅛	46⅜
Ash . . .	52	Bark on	38¼	41 1/16	73	30⅝	Heart of log	1 3 × 2	51¾	42	43¼	53⅛
		Bark off	36	36⅞	65½	34⅛	Outside	1 3 × 2	53¼	42⅜	42	52⅝
Elm . . .	70	Bark on	27¼	21⅛	76	29½	Heart of log	1 3 × 2	53⅝	37½	41¾	59⅜
		Bark off	25¼	18¼	65½	34⅛	Outside	1 3 × 2	54¾	38⅝	41	58
Beech . . .	70	Bark on	36	44 7/16	84 3/16	26⅔	Heart of log	1 3 × 2	63⅜	46½	35⅓	48⅛
		Bark off	35	42 5/16	80⅛	28	Outside	1 3 × 2	64⅛	45¾	34⅞	49
Birch . . .	70	Bark on	38½	43⅛	82¾	27	Heart of log	1 3 × 2	58½	40½	38¼	55⅓
		Bark off	34¾	37 5/16	71⅜	31¼	Outside	1 3 × 2	57⅜	42	39	53⅓
Sycamore . .	52	Bark on	39¾	52 5/16	87 9/16	25⅘	Heart of log	1 3 × 2	62¼	43½	36	51½
		Bark off	37¼	47	78 11/16	28⅔	Outside	1 3 × 2	63¾	46⅛	35⅛	48⅘
Horse-Chestnut .	52	Bark on	38½	40 9/16	69 17/32	32⅕	Heart of log	1 3 × 2	52⅛	32¼	43	69⅓
		Bark off	36½	35 13/16	61⅜	36½	Outside	1 3 × 2	53¼	33	42	67⅞

No remarks seem called for with regard to these last experimental results; for the figures speak clearly for themselves, and the reader can see at once what is represented by the different columns from the headings written on them.

Such information has a great practical value. For example, generally speaking, if a piece of Oak of 100 years' growth weighs 35 lb. with the bark on it, it will weigh only 31½ lb. after the bark is taken off it. Again, it is shown that 1 cubic ft. of Oak, of the age stated, weighs 90 lb. with the bark on, and only 81 lb. with it off, thus giving the weight of bark that may be expected from such timber per cubic foot in the green state.

Or again, 27⅝ ft. of unseasoned Oak of 100 years, with the bark off, make 1 ton; hence a wood-merchant, in removing such timber, could only take about this number of feet on one cart as a load. Such a consideration proves the great advantages resulting from the conversion of timber on the spot, as it is further shown that after the same timber is manufactured, although still in the green state, no less than from 32½ to 36 ft. of it can be conveyed by one horse, as 1 ton weight; and this makes a difference of 7 ft. to the ton on the average in favour of the converted timber. But a still greater difference is obtained by having the timber properly seasoned before it is removed to a distance. This is shown in the two last columns with reference to Oak of 100 years; for in these it is stated that although from 32½ to 36 ft. of the converted timber may be taken as a load of 1 ton weight while the wood is unseasoned, yet when it has been seasoned, no less than from 42 to 54⅝ ft. can be taken. These are facts worthy of the notice of all interested in the utilisation of timber, and may be strongly recommended for study.

These tables are simply the results of investigations in one particular locality, and can hardly be taken as anything more than mere approximations regarding the weights of the different classes of wood produced in different parts of Britain. In order to secure sound and reliable general information on such points, foresters generally will have to make similar experiments in all parts of the country, so as to ascertain the weight of the different kinds of timber per cubic foot, the number of feet that go to a ton, both in the round and after conversion, &c.

In making such experiments, however, additional data of various kinds might advantageously be noted. For example, in making experiments with regard to the weight of the timber of any particular kind of tree, it would be advantageous to state the character of the land on which it grew, its aspect, whether a hillside or a flat, the elevation above the sea, whether the land has been drained or was naturally dry, the exact age of the tree on which the experiment was made, its

dimensions, and whether it grew in a crowded plantation, &c., &c.; for the weight of any given kind of timber is much influenced by the nature of the land on which it grows, by the aspect of the situation, as well as by the absence or presence of much direct sunlight on the stems and branches, and also by the degree of moistness or coldness of the subsoil. To make complete and satisfactory experiments on this very interesting branch of forestry, therefore, all these points should be kept in view by the investigator; and, if possible, the experiments should be made on each kind of timber, at all ages, from 10 years old up to 100 years.

The Technical Qualities of Timber[1] are dependent on the amount and nature of the woody fibrous tissue or solid woody substance, on the quantity of water contained, and on the quantity and nature of the matter held in solution in the water.

The walls of the cellular tissue and the deposits contained by them consist of **Cellulose** so long as they belong to the cambium of the shrub or tree; but when they pass beyond the sphere of cambial activity, they gradually become thickened by lignified deposits and form **Lignin**. The former is much more supple and permeable for fluids, whilst the latter is stiff, hard, and less hygroscopic. In some softwoods there is no hard and fast division or line of demarcation between the sapwood or **alburnum**, and the heartwood or **duramen**, such as exists among the hardwoods (Oak, Ash, Elm, &c.). The timber of the softwoods is therefore, as a rule, less durable than that of the latter class, in which the heartwood becomes very hard and heavy through gradual and continuous thickening of the cell-walls by means of ligneous deposits.

The quantity of water contained in unseasoned wood amounts in general to about 45 per cent. of the total weight; but, of course, it varies according to—

(1.) *The species of tree.*
(2.) *The portion of the tree.*
(3.) *The nature of the soil and situation;* and
(4.) *The time of the year at which the timber is felled.*

In general the deciduous trees contain much more water than conifers; whilst trees felled in autumn contain least water, and those felled in the early part of summer most. According to Professor R. Hartig's experiments, the following appear to be the times at which the maxima and minima of water are to be found in the trees:—

Species of tree.	Maximum.	Minimum.
Birch	March	October
Oak	July	End of December
Beech	July and end of December	May and October
Scots Pine	End of December	May
Spruce	July	March and April
Larch	July	March and April

[1] For a full and masterly treatment of this subject, the attention of the student is directed to Gayer's *Forstbenutzung*, of which the eighth edition will immediately appear. The editor hopes shortly to bring out an authorised translation of this work in English, as well as of Gayer's other great masterpiece, his *Waldbau* or Sylviculture.

With regard to differences of colour between the sapwood and the heartwood, Gayer classifies the various species of trees as follows :—

I. **Heartwood Trees**, exhibiting marked differences in colour between the duramen and the alburnum : Oak, Chestnut, Robinia, Ash, Elm, Poplar, Willow, Yew, Juniper, Arborvitæ, Scots Pine, Mountain Pine, Weymouth Pine, Cembran Pine, Black Pines, and Larch.

II. **Intermediate Trees**, exhibiting no marked differences in colour, but distinctly differing with regard to the quantity of water respectively contained : Spruce, Silver Fir, Beech.

III. **Sapwood Trees**, in which there is no duramen differing from the alburnum either in colour or in the quantity of water contained : Birch, Lime, Alder, Maple and Sycamore, Hornbeam, Aspen.

The general proportion which exists between the respective amounts of timber, branchwood, and brushwood in woodland crops varies according to—

(1.) *The species of tree.*
(2.) *The density of the crop.*
(3.) *The age of the crop ;* and
(4.) *The nature of the soil and situation.*

Among the broad-leaved trees the most regular stems are formed by Alder, Oak (especially the sessile Oak), and Ash, then by Birch and Aspen; but the Conifers generally, and more particularly the shade-bearing genera, Spruce and Silver Fir, surpass even the light-demanding broad-leaved trees in their tendency towards the formation of a good bole.

As a general rule, the greater the density of crop, the larger will be the proportion of timber, and the smaller the relative proportion of branchwood and brushwood. Hence crops grown rationally in high timber forest must produce a larger proportion of long logs than is obtainable from standards or coppice.

In young woods the proportion of timber is of course small; but as the crops approach maturity the percentage of branchwood and brushwood decreases in woods that are managed on true sylvicultural principles, so that, in general, in crops of most species of trees which have been subjected to rational treatment, the percentage of timber contained in the stem amounts to from 80 to 90 per cent. of the total yield of wood. And as regards the nature of the soil and situation, the percentage of timber contained in the stems of the trees forming the crop is more or less directly proportional to the quality of the land.

The percentages of the different classes of wood yielded at an advanced age by the various kinds of high-timber forest-crops, of normal density, and growing on favourable soils and situations, is as follows (Gayer, *op. cit.*, p. 17) :—

Species of crops.	Percentage of total out-turn yielded by the		
	Stem.	Branchwood.	Brushwood.
Spruce	80 to 85	8 to 10	15 to 25
Silver Fir . . .	80 „ 85	8 „ 10	15 „ 30
Larch	76 „ 78	6 „ 8	12 „ 15
Scots Pine . . .	72 „ 75	8 „ 15	15 „ 20
Weymouth Pine . .	62 „ 80	5 „ 23	9 „ 20
Alder	75	8 „ 10	12 „ 15
Aspen	75 to 80	5 „ 10	5 „ 10
Birch	75 „ 80	5 „ 10	5 „ 12
Lime	65 „ 70	20 „ 25	12 „ 15
Elm	65 „ 70	10 „ 15	15 „ 20
Maple and Sycamore .	60 „ 65	10 „ 20	20 „ 25
Beech	60 „ 65	10 „ 20	20 „ 25
Ash	60	15 „ 20	15 „ 25
Oak	60	15 „ 25	20 „ 25
Hornbeam . . .	60	10 „ 20	15 „ 20

The percentages yielded by standards in copse is, according to Lauprecht, as follows :—

Standards of	Percentage of total out-turn yielded by the		
	Stem.	Branchwood.	Brushwood.
Oak	58	42	18 to 25
Beech	59 to 60	51	28 „ 40
Aspen	40	40	25 „ 29
Birch	35 to 40	35 to 44	34 „ 40

These figures must of course be taken as mere approximations, subject to subsequent corrections before they can be applied to British forestry.

With regard to the straightness of the stems, the various species of trees exhibit characteristic differences. The straightest boles are formed by Spruce and Silver Fir, and in a secondary degree by Scots Pine, Weymouth Pine, Alder, and sessile Oak. But, as is self-evident, the density of any given crop exerts a very decided influence on this particular matter with regard to most species of trees. Hence Scots Pine, Beech, Maple and Sycamore, Oak, Ash, and Hornbeam all gain in this respect by being grown in such density of canopy as does not absolutely interfere with the performance of their normal vegetative activity in assimilation and in the production of woody-fibrous tissue; whilst, at the same time, the freedom of the bole from branches and knots is directly dependent on the density of canopy that is maintained in any given crop. The importance of these two considerations can hardly be over-estimated with regard to the technical value of the timber for general purposes, which usually determines its financial or market value. The relative proportion of the top end of the bole, as compared with the butt end, is practically one of the other essential points that fix the selling-price of timber; hence whatever sylvicultural measures can be adopted to raise the *form-factor* of the stems forming the growing-crop must be worthy of the most careful attention of the forester, as well as the general method of stimulating the increment on timber crops approaching maturity by means of *partial clearance* and underplanting, when once they have completed their main growth in height after being

maintained in normal density of canopy throughout all their previous stages of development.[1]

The investigations of Sachs and R. Hartig have shown that there is no marked difference between the specific weight of the woody tissue of the chief species of wood, but that it is about 1·56, no matter whether the tests be conducted on Oak, Beech, Birch, Spruce, or Pine, or whether the woody tissue be taken from the sapwood or the heart. But, so far as the actual quantity of woody-fibrous tissue per unit of volume is concerned, the various species of trees show great differences, as broad-leaved trees contain in this respect from 25 to 30 per cent. more ligneous matter than conifers. The energy of growth of the trees, however, on which the amount of ligneous matter deposited essentially depends, is itself dependent on many factors connected with the *soil and situation*, and the amount of *light and warmth* available for the individual stem.

The following table, taken from Gayer (*op. cit.*, p. 27), may be convenient for a comparison of the average specific gravity of the wood of broad-leaved trees with that previously given for the coniferous species of timber (see vol. i. chap. iii. p. 331) and with Rait's data given in Table I. on p. 263 of this volume :—

Species of tree.	Green.	Seasoned.	Species of tree.	Green.	Seasoned.
Turkey Oak .	1·10	0·85	Chestnut . .	0·99	0·66
Pedunculate Oak .	1·04	0·76	Sycamore . .	0·93	0·66
Ash . . .	0·88	0·75	Birch . . .	0·96	0·65
Maple . . .	...	0·75	Plane . . .	...	0·58
Sessile Oak . .	1·01	0·74	Horse-Chestnut .	0·90	0·57
Hornbeam . .	1·05	0·74	Common Alder .	0·83	0·54
Robinia . .	0·87	0·73	Sallow or Saugh .	0·85	0·53
Pear-tree . .	1·05	0·73	Aspen . . .	0·81	0·51
Beech . . .	0·98	0·71	White Alder .	0·80	0·49
Elm . . .	0·95	0·69	Silver Poplar .	0·95	0·48
Apple-tree . .	1·01	0·67			

After seasoning, therefore, the following classification of woods may conveniently be made as to their weight for purposes of conveyance and utilisation :—

Very heavy (sp. gr. 0·75 or above): Turkey Oak, Yew, Pedunculate Oak, Ash, and Maple.

Heavy (sp. gr. 0·70 to 0·75): Sessile Oak, Hornbeam, Robinia, Pear-tree, (Teak), Beech.

Light (sp. gr. 0·55 to 0·70): Elm, Apple-tree, Chestnut, Sycamore, Birch, Larch, Horse-Chestnut.

Very light (sp. gr. under 0·55) : Alder, Willow, Scots Pine, Aspen, Black Pines, Poplar Silver Fir, Lime, Spruce, and Weymouth Pine.

With regard to hardness, Nördlinger classifies the different kinds of timber as follows :—

Hard: Robinia, Maple and Sycamore, Hornbeam, Wild Cherry, Yew, Pedunculate Oak.

Moderately hard: Ash, Holly, Plane, Turkey Oak, Elm, Beech, Sessile Oak.

Soft: Spruce, Silver Fir, Horse-Chestnut, Alder, Birch, Hazel, Juniper, Larch, Black Pines, Scots Pine, Sallow or Saugh.

Very soft: Weymouth Pine, all Poplars, most Willows, and Lime.

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[1] A detailed account of this operation will be found in the editor's *Studies in Forestry*, 1894, chap. x.

And with respect to elasticity, he ranges them thus :—

Very elastic: Yew, Larch, Spruce, Scots Pine, Silver Fir, Robinia, Oak, Chestnut, Ash, Maple and Sycamore, Weymouth Pine, Lime.

Less elastic: Poplar, Turkey Oak, Beech, Juniper, Aspen, Birch, Alder, Black Pines, Elm, Walnut.

He further classified them in the following scale with regard to shrinkage when undergoing the process of seasoning :—

Shrinking most (5 to 8 per cent. of the volume when green): Walnut, Lime, Beech, Hornbeam, Elm, Chestnut, Wild Cherry, Turkey Oak, Alder (?), Birch, Apple-tree.

Shrinking moderately (3 to 5 per cent. of the volume when green): Maple and Sycamore, Black Pines, Scots Pine, Poplar, Yew, Horse-Chestnut, Ash, Aspen, Sessile Oak, Robinia.

Shrinking least (2 to 3 per cent. of the volume when green): Weymouth Pine, Spruce, Larch, Silver Fir, Arborvitæ, Pedunculate Oak (?).

The shrinkage in length, *i.e.*, in the direction of the fibre, is only nominal; but it can amount to about 5 per cent. in the direction of the radius, and to about 10 per cent. in the direction of the circumference. And, of course, the greater and the more rapid the shrinkage, the greater will be the number and the depth of the cracks thus made in the wood. Hence the timber of trees felled in summer is more apt to be damaged for technical purposes than that yielded by those felled in autumn or winter.

The durability of timber depends mainly on the extent to which the wood is exposed to alternating changes from moisture to dryness, more especially during the warmer seasons of the year. It is under such special circumstances that the saprophytic fungi (mostly species of *Polyporus* and *Agaricus melleus*), which are the primary cause of the decomposition of the ligneous matter, find the conditions most favourable to their development and regeneration. Woods, however, which contain any comparatively large proportion of albuminoid substances will be more quickly attacked than those having a less proportion in their structure; and in the case of one and the same wood, the heavier specimen will at the same time be the more durable owing to the relatively larger deposits of lignin contained per unit of volume. And when once the saprophytic fungi have begun the work of decomposition, or often before then (as in the case of bark-beetles or *Scolytidæ*), insects attack the wood in order to deposit their ova or to feed on the starch, dextrin, &c., contained by the water still in the wood. But even long after the wood has become thoroughly seasoned it is still exposed to the attacks of fungi and of beetles like *Anobium*, *Ptilinus*, *Lymexylon*, &c. Experience shows that while growing crops of coniferous species of trees are most of all exposed to injury from insect enemies and parasitic fungi, yet seasoned timber of broad-leaved trees is more liable than coniferous wood to be attacked by saprophytic fungi and timber-boring insects,—and more particularly if the timber has been felled during the summer instead of during the autumn or winter.

When utilised entirely under water, Oak, Larch, Scots Pine, and Alder are far more durable than any other species of timber; but when exposed to changes of moisture, dryness, warmth, and cold, Oak, Larch, Scots Pine, and Black Pines rank highest.

With regard to their general durability, Gayer (*op. cit.*, p. 74) classifies the different kinds of wood as follows :—

Most durable.	Durable.	Least durable.
Pedunculate Oak. Larch, resinous, with large duramen, and grown at considerable elevations. Scots Pine, resinous, fully mature, and with broad summer zones in the annual rings. Black Pines (Austrian and Corsican). Robinia (*Acacia*). Chestnut. Elm.	Ash. Larch, grown at low elevations. Scots Pine, of quick growth, with smaller summer zones of wood, and less resinous. Spruce, from lofty elevations. Silver Fir.	Conifers of very rapid growth, and poor in resin. Beech. Hornbeam. Maple and Sycamore. Alder. Birch. Aspen. Lime. Weymouth Pine. Poplar, Hazel, Willow.

The soft-wooded and least durable species—Aspen, Lime, Poplar, Willow, and Weymouth Pine—are those which are most suitable for the preparation of cellulose or wood-pulp for paper manufacture, for which also large quantities of young Spruce and Silver Fir poles are utilised during the process of thinning.

Means of Improving the Technical Qualities of Timber.—Timber of well-matured growth, if sawn up immediately when felled, and properly seasoned and preserved from wet afterwards, will last for a great number of years; or if it be kept constantly saturated with water, it will last fully as long as when kept perfectly dry, and perhaps much longer. The best timber, however, if exposed to alternate changes of wetness and dryness, will last but a comparatively short time, as in the case of posts for fences, railway-sleepers, &c., &c. It has therefore become a matter of very considerable importance to railway companies, miners, and others who use wood to a large extent, to adopt some process of preparing their timber before they use it. With this object many experiments have been tried, some with considerable success, and others with little practical effect.

Timber of all kinds and ages will rot much sooner if used green than after it has been well seasoned, even if it should, after seasoning, be saturated with water and subjected to alternate wetness and dryness. This proves that a very considerable advantage is to be gained by drying all timber before utilising it for practical purposes. When once thoroughly seasoned first of all, the timber will last at least one-third longer than if used with the natural sap in it. This is a fact that does not seem to be generally understood by those who use wood for outdoor and pit purposes; for if it were duly recognised, then sleepers and props would not be used so soon after they are cut from the trees as is generally the case.

The Principle of Preserving Timber by Means of Impregnation is, therefore, to expel the natural sap, and afterwards to fill, so far as practicable, the open vessels of the woody fibre with some

antiseptic substance known to have the effect of preserving the tissues from the attacks of saprophytic fungi, from insects, and from natural decomposition; and of course this filling up of the vessels of the wood can only be effected by their absorbing the substance to be used in the state of solution in water, or by its being forced into them by pressure. One advantage to be gained from the adoption of such a mode is that the younger the timber, the more open is the fibre of the wood, and therefore the greater the quantity of the substance in solution which will be conveyed into the vessels; so that if the substance used be found at all to preserve the timber to which it is applied, it will have the greatest effect on young and soft-grown timber.

When lime is absorbed into the vessels, it is preservative of the timber. The way of applying this method is to take *slaked lime* or *hydrate of lime*, and mix it with water in a tank till the solution is quite thin and of a watery consistency. Into this tank any small timber can easily be put, after having been properly seasoned and sawn up for the purposes for which it may be wanted. It should be allowed to lie in the solution for a number of days, in proportion to the dimensions to which the timber is cut. If the scantling be small, such as boards, it may have absorbed enough in seven days after being put into the tank; but if somewhat large, it may require fourteen days; for large timber, however, about three weeks may be required.

As soon as the timber has been long enough in the tank to allow of sufficient absorption, it should be taken out, and afterwards thoroughly dried in order to expel all the water from it, when it can be applied to use. Timber treated in this way will last for upwards of twenty years as a fence.

Common salt or *chloride of sodium* is also preservative of timber. For this purpose it is dissolved in water in a tank, into which the timber is put to steep, in the same way as described above with reference to the lime solution; but with this difference that, as the salt held in the water enters the vessels of the wood much sooner than the lime does, the timber will generally be found impregnated with the salt solution in about half the time specified for the lime solution.

That salt is preservative of timber has long been well known to the timber merchants who live at Garmouth, on the seaside, at the mouth of the Spey. To this place large quantities of timber are floated down the Spey from Strathspey; and it has long been remarked by the inhabitants of Garmouth that the timber which lies longest in the salt sea-water, after it is floated down, is that which is most likely to last long for any purpose afterwards.

Another handy receipt for the impregnation of small timber

consists of 1 lb. of sulphate of copper mixed in 1 gallon of boiling water, to which 5 gallons of cold water are first added, and then, after mixing these thoroughly, 1 lb. of sulphuric acid or common oil of vitriol.

In using this, the tank should be filled to about one-third of its depth, when the timber to be steeped for preservation should be laid in it in a regular manner; the timber should be well seasoned before it is put into the tank. Twenty-four hours are sufficient for the steeping of timber of small scantling; but large scantling requires longer time in proportion. By steeping timber in this mixture it will last nearly double the time it usually does when used without such steeping.

On the estate of Glenelg, in Inverness-shire, all the timber used for fencing and other outdoor estate purposes is prepared by a very simple process. As soon as the timber is felled in the woods, it is converted into posts or whatever scantling may be required. These scantlings are then stored in a covered shed, left open on the sides and ends to admit of a free current of air. In this shed the pieces of wood are built in such an open and regular way that a current of air may pass freely through them; and, generally speaking, by the end of eighteen months, all the timber thus exposed is found to be well seasoned and fit for use. Before using it, however, even for the construction of a common paling, it is painted with *black varnish*, in order to prevent wet from getting into the vessels of the wood after it is exposed to the action of the weather; and by this simple process fences erected many years ago are still as good as when they were first put up. This mode of preparing wood for petty estate purposes seems worthy of the attention of foresters; and as it is a cheap method, any forester has it in his power to test it at a very slight cost.

Creosoting, or **Dead-Oiling** as it is called in North America, is an exactly similar operation. After the scantlings are thoroughly dried, they are put into a tank containing creosote, in which the timber is allowed to lie till it is saturated with the liquid, when it is taken out for use. Timber dealt with in this way is said to last many years for outdoor purposes, and as sleepers for railways.

The preservation of wood is indeed a national question with all civilised people at the present day; for where is the supply to come from some fifty years hence, seeing that demands for timber are on the increase, whilst the actual area under forest is annually decreasing? Every means should be used to endeavour to lessen this demand by preparing the timber so as to make it last longer; since it is clear that if timber can be made to last twice as long as it has done in the past, then only one half of the quantity now consumed could be made to answer the same requirements.

Iron, it is true, is now much used instead of wood for many purposes; but, notwithstanding this, the demand for wood is still upon the increase, owing chiefly to the extension of our mining and railway systems. It is therefore chiefly to the managers of these great branches of our national industry that we must look for economy in the use of wood.

The Pfister Process is the name of a new method of impregnating logs with zinc chloride in order to preserve them, which has been in use in Austria for several years. The timber is impregnated in the forest as soon as possible after it is felled. The zinc chloride solution has a sp. gr. of 1·01, and is forced into the thick end of the log by a force-pump. To this end an iron disc of suitable diameter and furnished with a cutting rim is forced into the end of the log and secured by clamps. The time required for this preliminary work is three or four minutes for each log. After a pressure of two or three atmospheres has been maintained at the thick end of the log for a few minutes, the sap begins to exude at the opposite end; and finally a weak solution of zinc chloride comes through, showing that the operation has been completed. About 2¼ gallons of the solution are required per cubic ft. of timber treated. Though rapid, the process does not appear to distribute the solution so uniformly as other methods.

Haskin's Process of Vulcanising Wood.[1]—The preservation of timber from decay when in use and exposed to climatic influences has always been an important matter, especially in connection with structural work. It has hitherto been held that the only way of effecting its preservation was to deprive it of every particle of sap or moisture, either by slow natural drying—seasoning, as it is termed—or by rapid exhaustion *in vacuo*. This method of procedure is in some cases supplemented by the injection of creosote, or of chemical solutions into the pores of the wood, according to the processes invented respectively by Mr Kyan, Sir William Burnett, and Mr John Bethel. Familiar examples of the creosoting process are timber railway-sleepers and wood road-paving blocks, which are heavily creosoted. There is, however, another process of preservation sometimes adopted, namely, that of charring the wood when it is to be inserted in the ground; and this is perhaps the oldest process of all, having been adopted in theory, as well as in practice, by people of all nations for many ages. Charring always ensures good results as regards preservation, but it has its drawbacks and its limitations. For instance, in order to get the heat to penetrate the wood beyond the charred surface, much of the timber has often to be burned away; hence the size and structural efficiency of the timber are reduced. It is not so much that the charred surface protects the interior of the wood from the action of either dryness or moisture, heat or cold, as that the heat developed during the charring process transforms the fluid substances into preservative solids, and at the same time destroys saprophytic fungi. The general character and appearance of the wood, however, remain unimpaired.

Following up the heat theory, Colonel Haskin, who has had considerable experience in creosoting timber in America, came to the conclusion that if he could retain the natural antiseptics contained in the wood, instead of depleting the timber of them and then partially reintroducing them, he would arrive much more quickly at a cheaper and more logical result.

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[1] See *Times* of 11th July 1892, and *Land and Water* of 18th November 1893.

Experience has proved the accuracy of his theory, which he has carried out in practice for some ten years past in America, where vulcanised wood has come extensively into use. The process consists simply in placing the timber, by small waggon-loads, in an air-tight retort and subjecting it to the high pressure of superheated air, the temperature of which varies from 300° to 700°. The time of exposure to the heat varies with the character of the timber, ordinary wood requiring about eight hours, and the hardwoods used for decorative and similar purposes requiring from ten to twenty hours to vulcanise. The heat is found to permeate the whole section of all the timber in the retort, thereby accomplishing the same result as the charring process, only in a much more thorough and efficient manner, without losing any of the sap or chemical properties of the wood and without waste. The process, however, goes further than this, inasmuch as the high temperature kills all the germs that may be found in the albuminoid portions of the timber which tend to breed and nourish fungi. In short, the effect of the process is to solidify the albuminoid matter throughout the tree, and at the same time to destroy bacteria or fungi, thus preserving the wood against decay. Another important result is attained through the wood becoming harder and stronger. Professor Alfred P. Trantwein, of Steven's Institute of Technology, Hoboken, New Jersey, who has extensively tested vulcanised wood in this connection, reports that his experiments establish the fact that vulcanising strengthens the wood, the modulus of rupture by transverse stress being 21 per cent. higher, and the crushing strength being increased 23 per cent.

An examination of samples of wood treated by Haskin's process seems to bear out all that is claimed for it, and the advantages are confirmed by the reports of Professor Chandler, Professor Theurston, and other well-known American experts and practical men. For example, a portion of a Pitch Pine sleeper, which has been under traffic on the Erie Railway for nine years, is apparently quite hard and sound. According to Mr Hain, the manager of the New York elevated railways, vulcanised Yellow Pine timbers have been in use on that line for the past six years, and do not show any signs of rot, whereas untreated timbers have decayed. It is stated that the cost of treating wood by the new process is far less than that of the creosoting and other processes, and that, so far as present experience goes, vulcanised wood is proof against the white ant and the teredo.

So far, however, as the true province of Sylviculture is concerned, the best means that the forester has at his command, in order to improve the technical quality of the raw produce he brings to the market, consist in—

1. The selection of suitable species of trees to form the crops under the given conditions of soil and situation;
2. The formation of woods of proper density for the species of trees selected, and the maintenance of normal density throughout all stages of the development of the crop;
3. The proper conduct of the operations of tending (weeding, cleaning, thinning);
4. And in rational treatment of the crop when it approaches maturity, either by thinning, or, preferably, by the method of *partial clearance* with simultaneous under-planting in the case of the light-demanding species.

CHAPTER XII.

THE PATHOLOGY OF FOREST-TREES.

I. The Healthy and Normal Growth of Trees.—A tree is an organised, living body, constructed mainly of cells and vessels, the vitality and growth of which are primarily maintained by means of the absorption of mineral food through its root-system and of the assimilation of carbonic acid in the foliage when exposed to light and warmth.

The body of a tree is formed out of a few earthy substances, together with water and air. It is fixed to the earth by its roots, and rises into the air in the form of a stem, bearing leaves, flowers, and fruit; but it has no power of locomotion.

As has elsewhere been remarked by the editor (*Soil and Situation in Relation to Forest Growth*, 1893, published by the Government of India for official circulation, p. 2):—

"In agriculture the productive capacity of land is to a great extent commensurate with the inorganic richness of the soil; but, as tree-growth utilises comparatively very much smaller quantities of mineral constituents (especially of those less common) than are demanded by agricultural produce, the sylvicultural capability of any soil is not determinable by the quantity of inorganic matter available for food-supplies, except perhaps in the case of the very poorest classes of forest-land.

"The actual quantities of mineral substance annually utilised per acre, as found in the ash of agricultural and forest produce, have been shown[1] to be as follows:—

Average of	Total quantity of ash.	Silica, SiO_2.	Potash, K_2O.	Lime, CaO.	Magnesia, MgO.	Phosphoric anhydride, P_2O_5.	Sulphuric anhydride, SO_3.	Other constituents.
Mixed agricultural produce . .	235	37	78	43	17	28	11	21
Woodland growth, timber and leaves.	126	29	11	62	10	8	3	3
Woodland growth, timber only . .	19	1·6	4	9	2	1·4	0·4	0·6
Approximate ratio of woodland to agricultural demand for mineral constituents . . .	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{7}$	$\frac{3}{2}$	$\frac{2}{3}$	$\frac{2}{7}$	$\frac{1}{4}$	$\frac{1}{7}$

[1] Ebermayer's *Physiologische Chemie der Pflanzen*, 1882, vol. i. p. 761.

"Weber[1] gives the average analysis of the dry timber of different species of European forest-trees as:—

50	per cent.	carbon.
42	"	oxygen.
6	"	hydrogen.
1	"	nitrogen.
1	"	ash.
100		

"As the total demand on mineral food-supplies made by woodland growth barely exceeds half of that made by agricultural produce, and as through the fall and decomposition of the leaves by far the greater portion of it is returned to the soil, it will be at once apparent that forests of normal density do not exhaust the soil to anything like the same extent as agricultural crops.

"According to Professor R. Hartig of Munich:[2]—

"'The quantity of mineral food taken up from the soil depends chiefly on the species, for some plants extract greater supplies than others. Thus the Spruce, for example, when growing along with the Beech in forests forming close canopy, extracts more raw mineral substance for ash than the latter. At fifty years of age the relative proportion of production between the Spruce and the Beech is—

As regards cubic contents of timber	2·78 to 1
As regards dry woody-fibrous tissue	1·80 " 1
As regards ash (mineral substance)	1·28 " 1

These figures prove that Spruce not only withdraws more nourishment from the soil than Beech, but that it also produces more timber than the Beech from any given quantity of mineral nutriment. For the production of any given cubic quantity of Beech timber more mineral matter is requisite than for the production of the same volume of Spruce.'"

A young tree is produced by seed derived from its parent tree. The seed of a tree, when acted upon by certain stimulating agencies, begins to exhibit life by germinating; these agencies are water, heat, light, air, and nutriment. The seed of a tree, if placed in earth at a temperature not exceeding 32° Fahrenheit, will remain inactive till it decays; but if it be placed in earth moistened with water, and having a temperature of some degrees above 32°, it gradually absorbs part of the moisture that surrounds it and swells. Its tissue thus becomes softened and stretches; the water is decomposed, and a part of its oxygen, combining with the carbon of the seed, forms carbonic acid, which is thrown off. Food for the young plant is prepared through the reserves of starch that are stored up within it being converted into dextrin or grape-sugar, by means of which the vital action of the embryo begins on the requisite temperature being attained.

The embryo lengthens downwards into the earth by the radicle or young root, and upwards into the air by the cotyledons. The latter acquire a green colour through the presence of a slight quantity of

[1] *Aufgaben der Forstwirthschaft* (Lorey's *Handbuch der Forstwissenschaft*), 1886, p. 72.
[2] *Anatomie und Physiologie der Pflanzen*, 1891, p. 227.

iron in their chlorophyll, during the process of decomposition of the carbonic acid which they absorb from the earth and the air.

A certain degree of moisture in the soil is a necessary condition for maintaining the vitality and the healthy development of trees at all stages of their existence, as their various organs are made up of cells, tubes, and vessels, requiring a free circulation of the sap throughout their structure.

The germination of the seed having taken place by the agencies of water, heat, light, and air, the young root lengthens at its point, and absorbs nourishment from the earth. This nutriment being conveyed to the summit of the plant by means of its cellular substance, it is partly forced into the seed-leaves, now expanding where it is exposed to the action of light and air. Here moisture is transpired; whilst at the same time nourishment is prepared for the maintenance and for the development of the organism by the processes of assimilation of atmospheric carbon, and the formation of carbo-hydrates to be utilised for structural and physiological purposes.

The current of sap rises continuously, by means of capillary attraction chiefly, upwards from the roots to the growing-point, which lengthens and forms a small twig; and at the same time the first portion of woody matter is formed from the descending sap in the centre of the radicle. The growing point, as it receives the sap, aërates it and sends it downwards. The root is thus enabled to form ramifications, while at the same time the gradual formation of woody matter takes place within the vessels of the young plant by the deposition of assimilated nourishment.

Before the growing-point begins to extend, it acquires the rudimentary state of a leaf; and this continues to develop as the growing point lengthens, until, when the first space between two leaves on the little twig ceases to increase, the first leaf has really attained its complete formation.

When the first leaf is fully developed, it carries on in a much more perfect mannner the functions previously performed by the seed-leaves; for assimilation becomes more vigorous, and the elaborated nutriment is passed in larger quantities downwards through the cambial layer of the bark to the root. Here it forms the first stratum of woody matter or cellulose, one portion of which is incorporated with the bark, whilst the remainder begins the formation of sapwood.

While this initial process of development is taking place, the cellular tissue of the stem is forming and expanding horizontally, in order to make room for the matter passing into it; hence development is at the same time progressing both in a horizontal and in a perpendicular direction.

Simultaneously with the primary development of woody-fibrous

tissue there also goes on the processes of formation of young roots, and their increase and ramification by constant, gradual increment of the cellular substance of their points. They thus assume something like a definite proportion to the leaves they are to support, and upon whose assimilative capacity their increment directly depends.

After the first leaf is produced by the growing point, others successively appear around it; all are formed alike, are connected with the stem in the same manner as the first, and perform in all respects similar functions. At last the growing-point or axis ceases to lengthen for the season, and the old leaves gradually fall off. Meanwhile a new set of leaves, instead of expanding after their formation, remain in their rudimentary state, harden, and fold over one another, so as to be a protection to the delicate point of growth,—or, in other words, become the bracts or scales of a leaf-bud. The ascending axis now consists of a shoot with a woody axis, and a distinct pith and bark, the whole assuming a more or less conical shape.

With the spring of the second year, and the return of warm weather, active vegetation recommences. The uppermost buds, and any others which were formed during the previous year, gradually unfold when the flow of sap is induced by the rise of temperature in spring; the place of the water transpired and the sap utilised is instantly filled by continuous supplies from below; circulation of sap is effected by an impulse being given to the fluids from the summit to the roots; fresh extension is given to the roots by new fibrils being thrown out; fresh food-supplies are absorbed from the earth, and sent upwards through the soft sapwood formed during the last year; and the phenomenon called the flow of the sap is fully accomplished, which continues with greater or less velocity till the return of winter. The growing-point lengthens upwards, forming leaves and buds in the same way as the parent shoot; a horizontal increase of the whole of the cellular system of the stem takes place; and each bud sends assimilated nourishment down through the *cambium* between the bark and the wood of the shoot from which it sprung, thus forming, on the one hand, a new layer of sapwood or alburnum, and on the other, a fresh deposit of bark or liber.

The food-supply, which is drawn from the earth and brought into circulation as sap by the unfolding leaves, are exposed, as in the previous year, to the chemical action of air and light, in connection with the processes of assimilation of atmospheric carbon and the preparation of carbo-hydrates; it is then returned through the leaf-stalk to the stem, and is sent downwards through the cambial layer to be from it either conveyed to the root, or distributed horizontally by diffusion throughout the cell-walls, or through the medullary rays connecting the periphery with the centre of the stem. At the end of the

year the same phenomena occur as took place during the previous season. Ligneous matter is gradually deposited throughout the period of active vegetation, and, as the last portion is denser than the first, this gives rise to the appearance of **annual rings** or concentric zones; the new shoot or shoots are prepared for entering upon the winter period of rest from active vegetation; leaf-buds in the shape of elongated cones are again gradually formed during the summer; and the original stem will have acquired an increase in diameter proportionate to the quantity of new foliage-bearing shoots which it has produced during the period of active vegetation extending from spring to autumn.

During the third year a similar process is repeated, but on a more extensive scale. More roots and rootlets are formed; food-supplies are again absorbed by the suction-roots from the soil, and conveyed to the leaves in the form of sap; and the loss of water owing to transpiration is made good by new fluids introduced into the roots and sent through the soft sapwood next to the bark. New cambial layers are formed, both on the wood and the bark, from assimilated nourishment sent downwards from the foliage; whilst the horizontal and the perpendicular developments of cellular tissue are both continued. Towards the end of the year wood is formed more slowly, and has a more compact character; and another annual ring appears, indicative of the current year's increment.

And in a precisely similar manner does the tree continue to vegetate, grow, and develop, till it is utilised by felling, or till the natural period sets in when it begins to show signs of senile decay. Each successive year brings a repetition of the phenomena of that which preceded it.

In addition to its essential utility with regard to cambial activity in its younger portions, the bark acts as a protection to the young and tender wood, by guarding it from cold and external accidents. It is also the medium in which the assimilated nourishment of the plant, in its descent from the leaves, is finally elaborated and utilised for the structural requirements peculiar to the given species of tree. Hence the character of timber is to a very great extent dependent upon the influence of the bark.

Leaves are at once organs of respiration, digestion, and nutrition. They elaborate the crude sap impelled into them from the stem by transpiring and decomposing its water, adding to its carbon during the process of assimilation, and exposing the whole to the action of the air; and they supply the necessary food to the young tissue that extends downwards from them by conveying to this, in the form of assimilated nourishment, the materials essential for the formation of new wood and bark. Thus, if a branch be deprived of leaves for a whole summer, it will either die or will not increase in size perceptibly.

After the leaves have performed their functions they fall off. This happens at extremely unequal periods in different species of trees. In most deciduous trees they all wither and fall off by the end of a single season; in others, as in the Beech and Oak, they wither in the autumn, but only fall off during the succeeding winter or spring; and in a third class they neither wither nor fall off at the end of the first season, but retain their verdure during the winter, and till long after the commencement of another year's growth. The latter is the case with evergreen trees.

The foregoing outline of some of the simpler facts of vegetable physiology with respect to the vital phenomena of trees[1] should be firmly rooted in the mind of every forester. There can be no doubt that the measure of success, both in Arboriculture and in Sylviculture, depends upon a correct understanding of the principles of vegetable physiology. The forester should be able to apply knowledge of this description to his daily operations, whether these may be the rearing of young plants in the seed-beds, planting them out in the woods, or thinning them whilst gradually developing into a crop of valuable timber. For it must be evident to every one who gives consideration to the subject that, unless the external influences by which plants are affected be clearly understood, a forester cannot possibly conduct sylvicultural operations on sound principles.

Among the principles deducible from the above physiological facts, and applicable to the every-day operations of the forester, it will be evident that at the very commencement of their existence, while still in the seed-bed, young seedlings will require to be attended to with respect to their natural demands for water, heat, light, air, and mineral food; and therefore the success of the forester in raising nursery crops will depend on the degree of intelligence with which he supplies these requirements. In the first place, he drains the land thoroughly, in order to remove all stagnant water from the subsoil, and thus increase its temperature; for the temperature of the soil and the subsoil is not less important to the healthy development of trees than that which is experienced above ground, and it is only by removing any injurious excess of moisture by drainage that the soil-temperature can be raised and improved.

In the next place, he digs the land deeply in the preparation of the seed-beds, makes the earth minutely friable, and renders it as porous as possible, at the same time adding to it well-prepared com-

[1] For a comprehensive and detailed exposition of this subject, the attention of the student is directed to the editor's translation of Professor R. Hartig's *Anatomy and Physiology of Plants, chiefly with reference to those of Sylvicultural Importance*, 1894. A more purely sylvicultural treatment of the subject may, however, be found in chaps. iii., iv., and v. of the *Studies in Forestry*, 1894.

post of leaf-mould to enrich it slightly; for, unless more or less of soil-preparation be carried out, fibrosity of rootlets and healthy vigorous development cannot be achieved, and it is only by the development of a good, vigorous root-system that proportionally strong and healthy stems can be formed from the nourishment prepared in the foliage for structural purposes.

By these operations of soil-improvement, then, the forester secures an increase of heat and of mineral food for the young plants he raises from seed on any piece of ground. After he has sown the seed he should be careful to keep the beds perfectly clean from weeds, knowing well that the latter would rob the soil of the food contained within it in the form of soluble salts, and that they would also prevent the development of the plants he had sown, by overshading them and keeping them from receiving the full benefits of light and air.

The advantages of light, heat, and favourable supplies of mineral food—although very decided and marked in the character of a crop of young trees properly dealt with while in the seed-bed, as compared with that of one reared under opposite circumstances—are, however, still more so in the case of the same kind of plants when they are transplanted into well-prepared ground in the nursery, as compared with others of the same sort taken from the same bed, and of the same age, but planted on land not previously prepared for them. Thus, a two-years' seedling Larch planted on a piece of waste ground, which may have been under the plough for some few years previously, will probably, at the end of the year, be found not to have made shoots of more than 5 in. during the season, or not to exceed 15 in. in average height; whilst other Larch plants taken from the same seedling-bed, and in every respect of the same character, but planted out on well-prepared ground in the nursery, should, at the end of the year, average upwards of 30 in. in height, and be strong and robust in proportion to their height. This very great difference in the characters of these Larch plants, taken from the same seed-bed and of the same health and strength of constitution when planted out, arises from seedlings which were planted out on old arable land having their roots excluded from the influence of the sun's rays by the thick turf and herbage growing on the surface; consequently it was late in the season before they commenced to grow; and even when their active period of vegetation did commence, it was not vigorous, as the natural herbage became stronger and stronger as the season advanced, and must have kept a considerable amount of warmth from their roots, which consequently remained in a state of comparative inaction. On the other hand, the seedlings transplanted into the nursery were placed under the most favourable circumstances with respect to the influence of heat. If the season be dry and warm, and if the ground be of a moderately rich

character, light in texture, and porous, the sun's heat will penetrate deeply into it, so as to cause the plants to grow rapidly even in the early part of the summer, before those in the field show any tendency to commence active vegetation. Under these circumstances it is obvious that one of the first of a forester's cares should be to secure, so far as possible, a warm temperature throughout the soil in which the young seedlings and transplants are raised; and this is only obtainable by drainage and soil-preparation.

It is also clear that, in transplanting seedlings from the nursery to the open ground where they are to grow into trees, the younger they are at the time of removal, the more easily will they establish themselves. Any one-year's seedling plant can be removed with nearly all its roots entire and uninjured, while a plant of two years' standing in the nursery must be deprived of a considerable proportion of its fibrous rootlets in the act of removing it; and the damage is apt to be greater at three years or at four, and so on in proportion to the number of years it may have stood before transplanting takes place. This is a physiological fact too seldom borne in mind by foresters; and, in consequence, in many parts of the country plantations of an unpromising character are to be seen, where a healthier crop might have been raised had more discrimination been used with regard to the age of the young plants used as the material for planting. As a general rule, the younger a plant is, the less is the disturbance to the organism caused by removal; while the older it is when removed, the greater is the amount of disturbance involved, and the less chance there is of its fully rehabilitating itself and thriving normally within the next few years.

The work of transpiration and assimilation, which forms the particular functions of leaves, is absolutely necessary to the health of a tree; and its healthiness varies in proportion to the degree in which these functions are properly and normally performed. Consequently, whatever tends to impede the free action of leaves tends also to diminish the healthiness of a tree. Sunlight is the principal agent for performing the vital functions of vegetation. When it strikes upon the foliage of a plant, either directly or indirectly, sunlight causes a decomposition of carbonic acid and an evolution of oxygen in the process of assimilation. This explains why there is generally more wood on the south side of a tree than on the north, also why depriving trees of their branches, and consequently of their leaves, must invariably be attended by a temporary diminution in the quantity of timber produced.

Important as are the functions of the leaves of trees with regard to transpiration, assimilation, and nutrition, yet this importance is not unfrequently ignored by some who have to deal with the tending

and management of woods. In many cases glaring ignorance is even exhibited with regard to the physiological facts connected with pruning or the removal of branches and foliage. Pruning ought not to be practised without a knowledge of the laws which regulate the healthy action of the organs of vegetation. If well and intelligently gone about, pruning may be advantageously applied; but if unskilfully practised, as is in Britain so often the case, it is highly injurious, and may even be destructive to the health and value of the trees operated on.

II. The Diseases of Trees.[1]—Even in the primeval forest, diseases are occasioned both by natural inorganic causes and by parasitic fungi, which occur sporadically as well as in a more or less epidemic form; and whenever roots, stems, shoots, or foliage are attacked by noxious insects, an unhealthy condition is induced, which predisposes the plants, poles, or trees to parasitic diseases, even though it may not occasion any such extensive disturbance to the normal functions of the various parts of the organism as to be in itself the primary and direct cause of disease and death. During the struggle for individual predominance and existence in the natural forest, the dominated and suppressed individual stems gradually lose their earlier vigour and energy of growth and then die off; whilst trees, produced from seed that has sprung up on spots unfavourable to the normal development of the species, are soon overtopped and suppressed by other species which find the soil better adapted to their special requirements.

In artificial forests and plantations, however, trees grow under conditions that are not so favourable to normal healthy development as wild growth in natural woods, where a young crop springs up when the parent stems die of senile decay; for the plants are often not indigenous to the soil, are more or less all of one age, and are all at nearly equal distances apart from each other. If the soil and situation be such as to satisfy the natural requirements of the given species of trees forming the crop, disease is infrequent. But if, on the contrary, the plants have not been well chosen for the given locality, then the crop, or any individual species forming a portion of it, may be more or less predisposed to disease in various forms and degrees, according to the proportion of unsuitableness in the condition of the soil to the particular species of trees.

Such **predisposition to disease** in trees is very often caused by

[1] For fuller treatment of this subject, the attention of the student is called to the following works treating more especially of the diseases of trees:—Marshall Ward's *Diseases of Conifers*, in *Jour. Royal Hort. Soc.*, vol. xiv. 1892, p. 124; Nisbet's translation of Kauschinger-Fürst's *Protection of Woodlands*, 1893, p. 57; Nisbet's *Studies in Forestry*, 1894, chaps. xiii. and xiv.; Somerville's translation of Hartig's *Text-book of the Diseases of Trees*, 1894.

unsuitability of soil. But in this country, where the woods often consist of a very great number of trees of different genera and species collected from different countries, there are also diseases arising from unsuitability of situation and of local climate; and these also take various forms, according to the degree of fitness or unfitness of the situation for the crops affected. For example, take any tree that is found to grow well with us in sheltered valleys, and place it on an exposed situation, the soil being the same in both cases; it will soon be found that some derangement has taken place in the performance of its functions. The symptoms of disturbance will vary less or more, according to the degree of exposure, and according to the peculiarities of the case. Again, on the other hand, take any tree that naturally grows at lofty elevations, with pure dry air, and place it in a low-lying, sheltered, and humid situation; although the character of the soil may be similar in both cases, the tree will be found to have undergone some change in its constitution, and will probably at an early stage begin to show more or less marked symptoms of predisposition to disease. The best means of preventing debility among woodland crops is, therefore, to select for each species of tree only such conditions of soil and situation as are known to be most favourable to the healthy or normal development of the species.

Speaking with regard to epidemic forms of fungoid diseases, especially frequent among coniferous crops of trees, Professor R. Hartig says (*Lehrbuch der Baumkrankheiten*, 1889, p. 45):—

"The best prophylactic measure against the occurrence and spread of epidemics is the cultivation of mixed forest crops."

Symptoms and Causes of Disease.—Trees, like animals, are subject to various diseases, which, if not prevented or obviated by removing their causes, often either make them die suddenly, or retard their growth to such an extent that senile decay is prematurely brought on. Disease in trees, like disease in animals, in all cases exhibits certain external symptoms by which it can be detected; but, in order to observe these, an experienced eye is required. To the inexperienced, trees will often appear healthy; while in reality they may be already diseased, or considerably predisposed to disease. Disease in trees, as in animals, is not confined to any particular stage of their existence; from the seedling just germinating, and the sapling in the nursery-row, to the full-grown mature tree in the forest, it may often be detected causing premature death. Although the symptoms are often plainly observable, they are frequently too little attended to by foresters; yet, as a general rule, trees are not apt to die either suddenly or prematurely when planted and existing under favourable circumstances as to soil and situation.

As in the case of animals, the healthy development of trees depends upon the supply of their normal requirements as to food. If any plant receive too little food, its development will be irregular and stunted. Again, if it be possible that a plant can take up more food than it can properly assimilate, the excess must predispose it to disease, and may induce some species of rot caused by parasitic fungi, or else lead to attacks from noxious insects.

Every tree in full health, if still considerably under the age of maturity, annually produces an elongation of all its branches, and a more or less proportionate increase in the diameter of its bole or stem according to the species; whilst the external bark, more especially in the hardwood sorts, should be comparatively clean and smooth. The amount of the increase of growth in any given time is not by any means, however, always a true criterion of the health of the stem.

The amount of increment mainly depends, *cæteris paribus*, on the amount of insolation, or exposure to light and warmth, that is enjoyed by the crown of foliage. When trees grow with free exposure of their crowns, transpiration is greater, assimilation is much more active, circulation of the sap is more rapid, and the deposition of ligneous tissue is more vigorous; hence the total increment and energy of growth are greater than when the individual growing-space is confined and circumscribed.

Again, trees growing in an exposed situation may be making but small annual layers of young wood as compared with others of the same species in a sheltered part; and at the same time they may be both equally healthy. Hence, in judging of the health of any tree or plantation, all given circumstances of the above nature must be taken into account. And although, in general, the external bark of trees in full health should be comparatively clean and smooth, yet this assertion must also be qualified; though a smooth and clean bark is usually characteristic of very young trees in rapid growth, yet with advancing age the exterior becomes more or less corticeous and rough according to the particular species of tree. Stems having a clean and smooth bark may often already be considerably damaged by inward disease; while, on the other hand, trees with a rough and furrowed bark may still be perfectly healthy and free from all disease.

It is not the author's intention to enter into details regarding all the diseases to which trees are liable in our climate. This would of itself form matter for more than one volume of ordinary dimensions. It is, in fact, more a branch of vegetable physiology than a subject belonging to such a book as the present, which is, strictly speaking, a plain practical work on the rearing of forest-trees. But it is necessary to advert to such diseases or want of normal vigour in forest-trees as may arise, in whole or in part, from bad management on the part of the forester; and, accordingly, the external symptoms of such diseases,

their general causes, the most likely means of cure where trees are infected, and the best methods of prevention of the principal and most common diseases, will all be briefly referred to.

A.—Non-Parasitic Diseases.

1. The Poisoning of Street-Trees.—This is a subject which has received considerable attention both in Britain and on the Continent of Europe. But perhaps the most succinct and condensed statement of our knowledge on the matter is to be found in the following extract from the *Report of the Secretary of Agriculture, U.S.A.*, for 1891, *Division of Forestry*, pp. 200–202.

"It has been observed in Cleveland, Ohio, that the street and lawn trees,[1] in which the city takes particular pride, were dying, and the Mayor and Council of the city called upon the Department to ascertain the cause. Professor S. C. Arthur, of Purdue University, Indiana, being an expert biologist, and in Washington at the time, was commissioned to act as an agent of the Department, and on his passage through Cleveland to examine the condition of the trees and their surroundings. From his report, and an additional report of the present writer, the following summing up of the case may be made, which will bear also upon similar cases in other cities.

"It is a well-known fact that trees in modern cities, especially street-trees, do not always find the most suitable conditions. Not only does the pavement and rapid drainage, which for other reasons is desirable and must be provided for, reduce available moisture supplies and impede aëration of the roots, but the trees are liable to various injuries, all of which conditions are apt to reduce their vigour and vitality. It is, therefore, necessary, first of all, to select for city planting trees which best endure such unfavourable conditions. Besides these unavoidable drawbacks to tree-life in cities, there exist additional dangers where leaks from gas-pipes saturate and poison the soil near the roots, and where, as in Cleveland, soft coal is burned in large quantities, from the sulphurous acid accompanying the smoke from such coal.

"From Professor Arthur's examination it appeared that the injuries to the trees which were dying did not proceed from the roots, and therefore had to be sought in the condition of the atmosphere. Subsequent correspondence, however, developed the fact that in localities where drainage and other conditions are favourable to tree-growth the trees did not die, in spite of the neighbourhood of iron industries giving rise to much smoke; which fact only goes to show that, under otherwise favourable conditions, trees, when unimpaired in their vigour, are able to resist the poisoning influence of the gases.

"Professor Arthur's opinion, then, may be accepted as properly explaining the cause of the destruction, and I quote from his report as follows:—

"'After giving due weight to the dryness of the soil, to the possible presence of illuminating gas in the soil, and to the discharge of gases in the air incident to the extensive manufacture of chemicals, some further cause must be sought for the unusual destruction of the shade trees of Cleveland; and such cause is to be found in

[1] Compare also section on *Trees in Towns*, vol. i. chap. iv.

the smoke from the large manufacturing establishments, and especially from the oil-refineries.

"'The action of smoke is twofold—mechanical and chemical. The mechanical action consists in excluding the light from the green cells of the leaf, and thereby preventing the formation of organic matter for the nutrition of the plant. In proportion as the light is excluded the plant languishes. The clouds of smoke that float above the tree temporarily cut off part of the light, and the coating of soot over the surface of the leaf acts continuously. Dust has a similar action, but is a less powerful absorbent of light, and is consequently less injurious. Rough-leaved trees suffer most, as the soot and dust are less readily removed by wind and rain.

"'The chemical action of the smoke arises mainly or entirely from the presence of certain gases which act as poisons. It has been found by Morren (*Prof. Intern. Hort. Exhib. in London*, 1886) that carbon monoxide, which arises from the incomplete combustion of coal, is not harmful to plants. Arsenic, in the form of arsenious acid, has been shown to be present sometimes in coal-smoke, but it does not appear to be specially injurious. Fluoric acid has recently been proven (*Forst- und Jagdzeitung*, 1891, p. 220) to seriously injure trees in the vicinity of establishments on the Rhine which manufacture fertilisers containing soluble phosphoric acid. I am unable, however, to give any opinion regarding the possible presence of fluoric acid in the air of Cleveland.

"'Probably the most injurious gas accompanying smoke from coal and rock-oil is sulphurous acid. It has been shown by Morren to injure plants if the air contains but one part in 50,000. More recent experiments by Schroeder (*Bot. Centralb.*, 1883, p. 368) make it certain that even one part in a million is harmful. Although I have no direct evidence of the presence of sulphurous acid in the Cleveland atmosphere, yet from the well-known abundance of sulphur in American soft coal and crude petroleum, there can be no reasonable doubt that it occurs in sufficient amount to largely or wholly account for the destruction of the trees.

"'Insect pests appeared to be less abundant in Cleveland than elsewhere; even the cottony scale of the Maples, which has been so destructive in other cities, was only seen a few times, and only in harmless numbers. I think that insects have no important part in causing the death of the trees.'

"The only exception that may be taken to Professor Arthur's statement is that the mechanical effect of the soot settling upon the leaves, while undoubtedly not favourable to the function of the leaves, is yet hardly to be mentioned as a cause of injury in comparison with that due to the acid poisoning. At least experiments made abroad would show the former damage hardly noticeable—the latter, on the contrary, easily determinable.

"Frequent suits for damages have led in Europe to a careful study of the effects of these gases, to the establishment of special methods for determining the connection between cause and effect, and to remedial legislation.

"The gases, which penetrate the leaves, not through the stomata, but by osmosis over the entire surface, act injuriously, directly by poisoning and indirectly by destroying the balance between water supply and transpiration, the sulphurous acid desiccating and destroying the tissues of the leaf.

"But the principal question is that of a remedy. No practical method of preventing the effects can be suggested as long as the smoke nuisance continues. Remedial action lies, therefore, only in two directions; either to prevent the escape of the noxious gases, or else to plant only such trees as are exempt, or partially so, from ill effects of the gases.

"High chimneys have not proved themselves altogether effective, but smoke-washing devices and methods of neutralising the acids by the use of milk of lime, or condensation to sulphuric acid, have been found practicable enough to permit in England such legislation as places chimneys under

police control, and imposes fines upon the owner who permits the escape of black smoke. The smoke-washing is a very simple and inexpensive operation, requiring nothing but a series of U-shaped flumes through which the smoke is made to pass under a sprinkle of water. Charcoal may also be employed to condense the gas.

"In some cities the establishment of factories is limited to certain districts, most suitably in the lee of the prevailing winds.

"As regards the choice of trees which would withstand best the influence of the gases, it may be said that where the smoke nuisance is excessive none will survive. The Conifers suffer most. Of deciduous trees the Alder, which can hardly be considered a desirable street tree, and the Sycamore, seem hardiest; next come the Poplars, the Ash, and the Linden, and the very ornamental Mountain-Ash, which deserves more attention than it has as yet received. As to the Elm, experiences seem to differ; probably otherwise very favourable conditions of growth, which, however, are rarely found in cities, may enable it to resist the effects of the smoke. The Norway Maple seems to excel our American kinds in smoke-resisting quality. Ailanthus, Horse-Chestnut, and Black Locust are also mentioned as available. I am inclined to add to the list of those probably capable of resisting acid-poisoning the Sweet Gum or Liquid Amber, which in every respect is one of the most commendable street-trees, and also the Tulip Poplar.

"I may add that if effective measures were taken at once to suppress the smoke nuisance, it would probably be possible to save by judicious pruning such trees as are not too badly affected, and have retained vigour enough to make new growth.

"Of course, before the city authorities will act in such a matter, a more thorough examination by competent chemists and fuller report upon practicable means of averting the damage would be necessary.

"I cannot leave this subject of growing importance to many other cities besides Cleveland, Pittsburg, Cincinnati, St. Louis, &c., without pointing out, first, the need for these cities to consider the disadvantages, not only to plant life, but to human health and life, which arise from the unrestricted contamination of the air by the smoke nuisance, quite unnecessarily; and, second, the desirability of having the tree-planting in the streets and public grounds superintended and carefully directed by competent men. When it is considered that the maintenance of the parks and street trees of Washington involves an annual expenditure of over $125,000, or the interest on $2,500,000, the importance, from a mere financial point of view, of guarding this most valuable health-promoting property against avoidable injurious influences becomes clear. The city of Cleveland, beautiful and attractive through its verdure of luxuriant trees, may well be alarmed at her loss, and stand ready to guard her trees with jealous care."

The illustrations on opposite page (Figs. 296, 297, and 298), (from Ramann's *Forstliche Bodenkunde und Standortslehre*, 1893, pp. 337 and 341), exhibit the effects of the poisonous action of sulphurous and nitric acids on the foliage of Oak and Scots Pine.

2. Bark-Bound Trees.—This abnormal condition of the stem may very frequently be found in broad-leaved species of trees growing in soils or situations not naturally suited to their normal requirements. The external appearance of a tree consists in the outer bark being hard and compressed, and of a dry coriaceous or leathery texture. If the disease be not of long standing upon a tree, any

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Fig. 298.

Oak Leaf damaged by Nitric Acid. The dark-coloured edging of the leaf is dead.

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[1] *gy of Plants*, 1886, p. 40.

creates a disturbance within the organism by preventing the free upward flow of the sap from the roots to the leaves, and also by hindering the descent of the assimilated nourishment between the wood and the bark.

When trees become bark-bound in this manner, the only true sylvicultural treatment is to remove them and cultivate other species for which the soil and situation are more favourable. This may easily be done by cutting out the diseased individual stems during the ordinary operations of thinning.

Sun-burn or Scorching of the Bark is a diseased condition occasioned by exposure of the stem to the burning influence of the direct rays of the sun or to those refracted from the soil. It causes the bark to lose its turgidity, and consequently to become dry and dead. It only occurs on the south, south-west, and west sides of trees, and is, in close-canopied crops, only found when trees are suddenly exposed to the sun after having long enjoyed the protection of adjoining trees; but it can often be the result of injudicious thinning or pruning in ornamental woods or in park trees, when this is carried so far as to remove stems or branches that had previously protected the lower portions of the bole of the tree affected.

Concerning this disease the following remarks are made in the editor's translation of Kauschinger-Fürst's *Protection of Woodlands*, 1893, p. 20:—

"The trees which suffer from sun-burn are invariably such as, even in their later stages of growth, have a smooth bark without any rugged corky protection; that is to say, the Beech in particular, and in a less degree Hornbeam, Ash, Maple, Sycamore, and young Spruce and Silver Fir. Species with rough corticeous bark, like Oak and Elm, do not suffer at all, or are at any rate only exposed to danger during the earliest period of their growth, before the thicker fissured bark begins to form. The danger begins about the pole-forest stage of growth; but older trees are more sensitive in this respect, and exposed to greater danger. In the case of Beech, which is very sensitive to insolation, the appearance of sun-burn can often be noted even on large trimmed transplants; it usually results in their dying off.

"Preventive measures consist in the avoidance, so far as possible, of sudden exposure of the edges of woodlands, and of the retention of all branch development there; timely formation of a protective belt by planting up with Spruce can also prove efficacious. Beech-trees that have hitherto been growing in the close canopy of high forests, but are now retained as standards for the production of large timber, almost invariably after a short time show the occurrence of sun-burn; hence the retention of such individual standards is not advisable. Sun-burnt stems along the edge of woods should, however, be retained as long as possible, as they remain for a long time in active vegetation; whilst, if they be removed, the stems immediately behind them would then be exposed to precisely the same danger."

3. Moss or Lichen upon the Bark.—In a normal state of growth, the bark of healthy trees is clean and free from any undue development of moss and lichens. They may, however, be found to exist to a slight extent upon trees in a variety of circumstances, soils, and situations, without always being a symptom of unhealthiness. In any district of country where much rain falls, almost all trees will, to a certain extent, be found to support moss and lichens, without the

stems being in what might reasonably be termed an unhealthy condition of growth. But the tendency to become a support for organisms of lowlier form, and to be much overgrown with lichen, exists to the greatest extent in a damp humid atmosphere, where the trees have not a free circulation of air about them. In this case a diseased state of the trees cannot be said to be the cause of the lichen growing upon them; yet such trees, existing in a state of air favourable to the development of the lichen-spores upon their stems, may be ultimately much injured by the plants choking the lenticels of the bark. And in this case, draining of the soil so as to carry off all superfluous moisture, thinning the trees judiciously so as to admit a free current of air, and removing the lichen from the bark, will generally completely restore them. But, if those requisites of health have been too long neglected, it may often be impossible to effect a cure. Trees existing in a high and exposed situation, more especially if the subsoil upon which they are growing is cold and damp, are almost always apt to be injured both by moss and lichen.

In the *Centralblatt für das gesammte Forstwesen* for 1889, p. 275, a case is detailed in which the woodlands in a damp mountain valley, with a crop of Spruce, Larch, and Scots Pine, suffered to such an extent from being overgrown with eight species of lichens, that about 50 per cent. of the trees were dying prematurely.

4. **Diseases occasioned by Frost** include not only the *damage done by early and late frosts*, often resulting in the death of the seedlings and young plants, but also *frost-shakes* made on the outer portions of poles or trees, and *heart-shakes*, occasioned by the action of hard winter frost.

The cause of the damage done by early frosts in autumn, and more particularly by late frosts in spring, is the withdrawal of water from the cells into the intercellular spaces, so as to cause loss of turgidity in the tissue, in consequence of which the parts affected die off when a thaw sets in, as they are no longer able to perform their normal functions. Species of plants that break early into leaf in spring are naturally less sensitive to the effects of sudden changes in the atmospheric temperature than Oak, Chestnut, and Robinia, which only flush their young foliage between the middle and the end of May.

The use of strong, sturdy transplants is to be recommended for localities liable to be visited by frosts in spring and autumn; whilst the sylvicultural means at our command for obviating risk and minimising danger are thus summarised by Kauschinger-Fürst (*op. cit.*, p. 10):—

"The chief preventive measures which can be applied on a large scale for the protection of young plantations and thickets consist in the formation and reproduction of crops of trees liable to suffer from frost, especially of Beech and Silver Fir, under protective or parent standards, maintenance of fairly dense canopy or shelter overhead, and gradual removal or clearance of the same, avoidance of sudden, usually very injurious, exposure of the young growth thus formed or reproduced, and maintenance of a protective belt on the east and north-east sides till the chief period of danger for the young crop is at an end. Hardy softwoods, like Aspen and Birch, which often assert themselves spontaneously in large numbers among the young growth,

may form a very desirable protection for the more sensitive species, in which case they should only be gradually cleared or weeded out.

"Where natural protective standards are wanting in localities exposed to danger from frost, they can be artificially produced by means of hardy woods of speedy growth, like Pine, Birch, or Alder, which should be planted out in rows somewhat wide apart. When these have attained a height suitable to afford protection, the planting out of the species requiring shelter can take place between the rows; and when the main crop has developed so far as to be above the frost-height, the protective species can then be gradually removed. Patches that are essentially frost-holes should always, when possible, be planted up with hardy species."

Frost-shakes are caused by excessive and rapid shrinkage of the bark and sapwood during intense frost. Whenever the extent and the rate of shrinkage exceed a certain limit, varying according to the species of tree, a sudden rupture of the woody-fibrous tissue takes place along the line of least resistance, and is usually accompanied by a loud noise. The clefts or frost-shakes thus formed sometimes extend all along the bole. When the thaw occurs, the woody-fibrous tissue again expands so as to nearly close up the wound, which cicatrises by the formation of a ridge of callus tissue. This operation may be repeated almost every winter, or the cleft may remain closed during a succession of mild winters; but the frost-shake remains visible as a long excrescence standing out somewhat from the ordinary contour of the stem. With regard to this abnormal or diseased condition of the trunks of trees Kauschinger-Fürst remark (*op. cit.*, p. 13) that—

"Hardwoods with strongly developed medullary rays, like Oak, Elm, and Sweet Chestnut, are chiefly exposed to the danger of forming frost-shakes; they are also, but less frequently, formed in Beech, a few softwoods (Lime, Poplar, Willow), and Conifers. They are especially to be found on old isolated stems, or on standards in copse or in high-forest, and usually occur on the east and north-east sides of the stems, as the harder frosts only set in when the wind comes from these directions, and consequently work most powerfully on these sides. Low-lying tracts and localities with fresh or moist soil are more exposed than others to this particular danger.

"Preventive measures can hardly be applied to mitigate this evil; but the early utilisation of trees with bad frost-shakes is recommendable in view of the liability to which they become exposed to fungoid disease, and consequent depreciation in value."

5. Stag-Headedness.—This symptom is easily distinguished from all others by the top and upper branches of the tree affected becoming dead and quite bare of all leaves and young twigs, and having the appearance of stag's horns. Willows and Poplars, which luxuriate in a soil rather damp than otherwise, generally become stag-horn-topped when grown in a soil too dry for their healthy development. This occurs as soon as they have arrived at such maturity upon the soil upon which they may be growing as its nature is capable of bringing them to. It at once indicates their premature state; and the wisest thing is to cut them down, seeing that the soil is not adapted for their growth. Elm, Oak, Ash, Sycamore, &c., generally become stag-headed, when they are exposed freely to light and air after having stood in close canopy, through the sap being diverted, in its upward flow, towards the forma-

tion of shoots from adventitious or dormant buds upon the stem, which are now for the first time called into active life by the sunlight and warmth; hence the upper portion of the crown does not receive its proper share of food, and consequently gradually dies of starvation.

Regarding this local condition of disease, Professor R. Hartig (*Lehrbuch der Baumkrankheiten*, 1889, p. 14), remarks:—

"Oaks which have grown up in close canopy along with Beech, and have only a slightly-developed crown of foliage, acquire a predisposition towards dying off at the top of the crown (stag-headedness) when they become fully exposed to light and air; whilst, under similar conditions, trees with well-developed crowns do not suffer from this disease."

This atrophy of the upper portion of the crown may be obviated by *gradually* accustoming standard trees to increased growing-space and larger supplies of light and air.

And, as the editor has elsewhere explained with reference to *partial clearances* in valuable crops approaching maturity (*Studies in Forestry*, 1894, chap. x.):—

"The nature of the development of the crown is, however, of greater importance than the age of the crop; for if the previous thinnings have been neglected, and the canopy has been allowed to remain so dense that the woods are crowded, it often happens that, on receiving increased growing-space, the trees with their weakly crowns are unable to avail themselves of the advantages thereby offered, and exhibit, as is often the case with Oaks, a tendency to development of dormant buds, which leads to **stag-headedness**, or death of the crown and malformation of the bole."

6. **Premature Seeding** is not in any way a disease, but is merely the symptom of an abnormal condition, which finds its natural expression in an abnormal tendency towards reproduction of the species. Trees in a healthy rapid-growing state are seldom found to produce seed till they have arrived at a considerable age and size. Generally speaking, any forest-tree bearing much seed under forty years of age is not likely, ultimately, to arrive at a valuable size. Any tree, however healthy a state it may be in, may be made to bear seed by creating an unnatural disturbance within the organism, as, for example, by mutilating its roots or its stem; but where a young tree produces seed largely, at any abnormally premature age, without any visible outward injuries having been inflicted, it can hardly be in a healthy condition. The premature bearing of much seed in the Larch, for example, is almost a sure index of heart-rot in the trees; and even in the cases of Pines of any kind, the bearing of much seed in their young state at once points to weakness of constitution, and indicates that the trees are not likely to become valuable as timber, but that they will culminate in increment prematurely at a comparatively early stage. Many of the newer coniferæ are found to bear seed at a very early stage, and still have the appearance of continuing to make fair progress; but this early bearing of seed is probably a sign that they have not yet thoroughly acclimatised themselves.

All kinds of trees, but more especially the broad-leaved species, store up large *reserve supplies of nutrients* annually, which are utilised for the development of the buds in the following year, and for all the processes of awakening vegetation until assimilation is conducted independently of their assistance. But in any abnormal or diseased condition there is what might be called an instinctive tendency or involuntary impulse to the utilisation of an abnormally large proportion of these nutrient reserves in the formation of flowering buds for the production of seed in order to reproduce the individual.

7. **Stunted Growth** is also in young crops merely the outward and visible sign or manifestation of an abnormal inward condition of the organism. This state of a tree is at once apparent by the very short annual growth of young wood upon all the lateral branches. Every healthy tree ought gradually to reach its culmination in rate of growth in height, and then gradually sink in rate of growth after the culminating point has been attained. If, however, a tree of thirty years of age makes shoots of 12 in. annually, and soon after that period is found to be making shoots of 4 in. only, then there is reason to suspect that it has become suddenly unhealthy. The cause may either be sought for in some one or other of the diseases already mentioned, or it may be due solely to the unfavourable nature of the soil, and more particularly of the subsoil.

8. **Wound-Rot.**—It sometimes happens that trees receive damage to their stems through having the bark peeled off by accident in some way or other, which may prove injurious to their health, and may not unfrequently be the cause of death. Any tree in a healthy state is not easily injured beyond power of recuperation by an external wound upon the bark, unless, indeed, that be very extensive, as is frequently the case with cattle stripping the bark, when the tree will gradually decline in health, and may ultimately die. But any simple damage received upon the bark of a healthy tree in all cases soon heals up, and is only of a temporary nature.

If, however, cup-shaped hollows are formed which retain the moisture, or open-wound surfaces afford ingress to fungoid spores, then the process of decomposition of the woody-fibrous tissue is often rapid, and may extend far down or into the stem. The work of decomposition is often solely due to parasitic fungi, but may also be largely due to other causes. Inorganic and organic causes generally, however, work together in the matter, although most damage is due to the fungoid infection.

B.—The Parasitic Disorders.

I. **Fungoid Diseases.**—The parasitic fungoid diseases are by far the most important from a sylvicultural point of view. Infection with fungoid spores can take place at any wound-surface, as, for instance, wounds caused

by pruning, by stripping off the bark, &c., or by the boring of beetles, or by the punctures formed by insects in foliage and young shoots, &c.

This very comprehensive class of diseases may be subdivided conveniently into—

1. Diseases of seedlings and young plants.
2. Diseases of the foliage on older plants.
3. Diseases of the branches and stem.
4. Diseases of the roots of older plants.

These can merely be glanced at here, but the attention of the student has already been directed to the works in which further information may be had on this special subject (see p. 285).

(1.) **Diseases of Seedlings and Young Plants** are frequently occasioned, more especially in nurseries, by the following species of fungi (Gayer, *Waldbau*, p. 330):—

Hysterium Pinastri, which is one of the principal, though not the sole, cause of the **leaf-shedding** so common in Scots Pine, the Noble Spruce (*Picea nobilis*), and other Conifers. A similar phenomenon may also be occasioned either by frost or by drought; but there can be no doubt that the vast majority of cases of the disease are directly caused by this parasitic fungus. Of the many means that have been recommended for preventing the climatic form of the disease in nurseries, the best seems to be covering up the beds in late winter with twigs of Birch and Beech, so as to hinder the plants being stimulated to too early and active transpiration; whilst the use of Pine or Spruce twigs would only augment the danger of infection with the fungoid form of the disease.

Agaricus melleus and *Trametes radiciperda* (see Figs. 310, 309, p. 306) kill coniferous plants of several years of age. The former is recognisable by its large white mycelial filaments under the bark near the tops of the roots, and by its black strands or rhizomorpha; whilst the latter is characterised by small white patches of mycelium under the bark at the top of the roots, and by a white hymenial layer on the spore-producers, which appear most frequently on the roots and below the base of the trunk. Both of these fungi commit great havoc in nurseries and young plantations.

Phytophthora omnivora causes disease both in broad-leaved species and in conifers; its ravages extend to areas being regenerated naturally as well as to nurseries. Seedlings of Beech are especially apt to be attacked, when large black patches become visible on the cotyledons, the primary leaves, and the shoots. Beech, Maple, Sycamore, Spruce, Silver Fir, and Larch are the species of trees principally liable to its attacks. The disease only infects germinating seedlings, and does not extend to nursery-beds.

Cercospora acerina is a somewhat similar form of disease, which attacks young Maple and Sycamore seedlings in their first year. When the small black patches extend to the stem as well as to the cotyledons and primordial leaves, the death of the plant generally ensues.

Rosellinia quercina attacks one and two-year-old Oaks in the seed-beds and nursery-lines. The plants die off during the summer, and then black pustules appear on the roots and near the base of the stem.

Pestalozzia Hartigii attacks yearling seedlings to four or six-year-old plants of Spruce, Silver Fir, and other species of trees, and kills them in patches on the seed-beds before autumn. The outward sign of this disease consists in a bending down of the stem just above the soil.

Herpotrichia nigra is of not infrequent occurrence on Spruce, Mountain-Pine, and Juniper, killing young plants of several years of age. It is,

[illegible] in cold mountainous tracts, and not [illegible] tered localities.

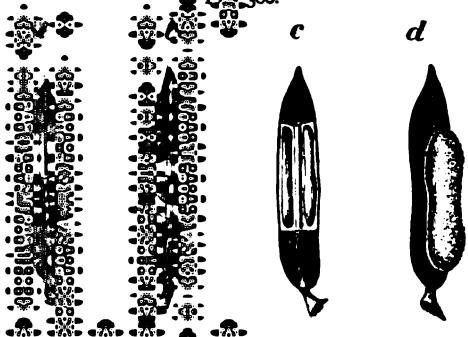
[illegible] Older Plants.—In addition to the [illegible]

[illegible] 299.

[illegible] *d by Rust* (Chrysomyxa abietis).

[illegible] and blights occasioned on various [illegible] *æ* and *Aphidæ*, &c., there are several [illegible] g from infection with parasitic fungi.

[illegible] 300.



[illegible] *bout the end of June or early in July.*
[illegible] *the autumn.*
[illegible] *ule in the following spring.*

[illegible] igs. 299 and 300) may be taken as a [illegible] arasitic diseases of coniferous trees; it

ngs to the *Uredineæ*.
ng description of the
nted by the formation

) occurs on the young
yellow, while the parts
n golden-yellow puffed-
urst and scatter their
ptying of the fungous

301.

w Rust (Melampsora salicis)
ier (Salix pruinosa).

ng the pustules.
lready dried up.
alk near the base of the leaf.

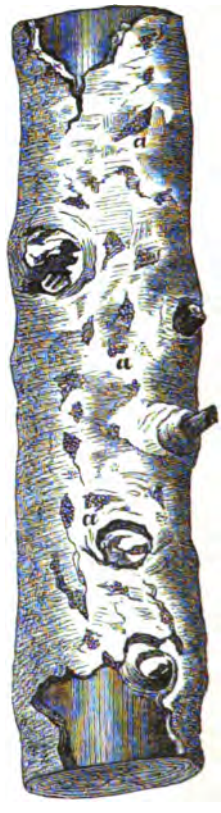
isma acerinum. More
elampsora Tremulæ on
those of the Birch, as
Cœoma pinitorquum,
the Pine, and of the
where fungoid disease
be cut out of Pine and

and *M. Hartigii*, which
wing on several shrubs,

[illegible] and Stem.—Of these there are many; [illegible] their effects. The chief diseases of this [illegible] follows :—

[illegible] by *Æcidium pini v. corticola* (Fig. 302).
" *Æcidium elatinum.*
" *Nectria curcubitula* (Fig. 303).
" *Trametes pini* (Fig. 304).
" *Peziza Willkommii* (Fig. 305).
" *Nectria ditissima* (Fig. 306).
" *Cœoma pinitorquum* (Figs. 307, 308).
" Species of *Polyporus* chiefly.

Fig. 303.

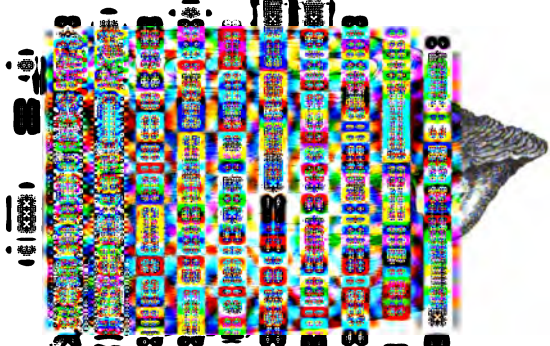


Showing nature of damage done to a young Spruce stem by Nectria curcubitula.

a. Perithecia *as they appear whilst hibernating.*

[illegible] given above showing where more detailed [illegible] ing these different classes of diseases, [illegible] ntion here solely to one type; and for

[illegible] ease as it is commonly [illegible] portance, be selected.



[illegible] ole by the [illegible] them.

[illegible] eziza Willkommii.

[illegible] h.

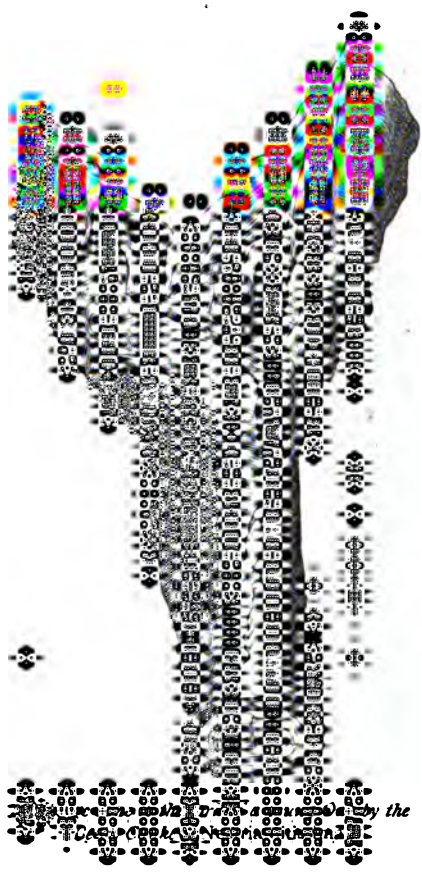
[illegible] eziza.

[illegible] 305) is thus described [illegible]

[illegible] very widespread disease, [illegible] s, according to Hartig's

[illegible] unate results that have in many places [illegible] this species. On the spores germinat- [illegible] rk wherever it can find any damaged [illegible] nding of the branches under ice, &c. [illegible] ssue and kills the portion attacked; [illegible] outwardly visible by the bursting of [illegible] e. Small cup-shaped fungi with bright

306.



[illegible] by the [illegible]

Damage done to the stem of a young Beech by Nectria ditissima.

a. Clusters of red perithecia, *as seen during the winter months.*

b. Canker spots, exposing the dead wood.

[illegible] cted places, indicating the cause of the [illegible] and can finally extend all round the cir- [illegible] s off above the diseased ring; but when [illegible] m, this may continue alive for decades. [illegible] fungus has obtained in low-lying tracts [illegible] ess frequent occurrence and much less [illegible] home of the Larch, Hartig thinks

[illegible] agnating atmosphere of [illegible] has been introduced as a [illegible] attain a more luxuriant [illegible]. In the dense forests [illegible] ng and making use of a [illegible] forests of the Alps, con-

308.

[illegible] of the damage occa-[illegible] ns of young Pines by [illegible] um. The abnormal [illegible] by the attacks of the

[illegible] fungus generally dry up [illegible]

[illegible] nations the Larch suffers [illegible] is fungus is well known; [illegible] n the avoidance of such [illegible] mixed forests, by means [illegible]

[illegible] dge of the Larch disease [illegible] is seems to the editor

advisable to give here also the following quotation from Marshall Ward (*op. cit.*, p. 143):—

"This *Peziza* develops from its spores a mycelium which, when once it has established a hold in the inner cortex of a branch of the Larch, can go on growing and extending into the cambium; this it kills, destroying a larger area year by year, and producing the so-called canker patch, which is simply a shrivelled mass of dead tissues impregnated with exuded turpentine or resin. If the dead patch extends all round the branch or stem, all the parts above may die off, partly because, the cambium being destroyed, there is no more wood developed at that region to carry up the water supplies to the leaves, and partly because the resin blocks up the wood which it permeates.

"To understand how it is that the Larch fungus spreads so rapidly and with such dire effect in Great Britain, it is necessary to note some peculiarities not always properly appreciated.

"*Peziza Willkommii*, like other fungi, requires merely water, oxygen, and a suitable (not to say high) temperature for the germination of its spores: given these, the germinal hyphæ are developed anywhere. The mere *germination* of a spore may, therefore, take place on any damp surface exposed to the air, *e.g.*, the soil, the bark of old trees, or the thin cortex and leaves of the twigs and young trees, &c. But millions of spores may go through this process of germination, and then the germinal hyphæ die off for want of further food supplies, whereas if any one of these hyphæ finds its way into the succulent cortex of a Larch, it is nourished at the expense of the tissues, spreads into the cambium, and brings about the disease referred to as the 'canker' of the Larch.

"As matter of experiment—and only by experiment can we arrive at such knowledge—it is found that if spores of this fungus germinate on the sound bark, cortex, leaf, or other part of the Larch-tree, the germinal hyphæ fail to effect an entrance; if, on the other hand, the spores are sown on a wound, however slight, in the cortex of the tree, it is able to enter and infect the latter.

"Now the thin cortical covering of a young Larch stem or branch is a dangerously tender envelope to the tissues below, and it is rapidly protected later on by a rather thick coating of cork. As a matter of fact, the corky 'periderm' begins to form just below the epidermis before the end of the first year, and is increased every year afterwards. When the tree is about twenty years old the real bark begins to be formed, owing to the development of internal layers of cork.

"Obviously the period most dangerous to the Larch is that during which its cortex is still tender and its leaves succulent and delicate. In its Alpine home this period is rapidly passed through; in the lowlands of Europe, and in damp insular climates, this period is apt to be a dilatory one, and severe checks from frost, cold winds, periods of dull, misty, 'sunless' days, &c., are apt to cause the trees to suffer in all kinds of ways. But such periods are not calculated to check the spread of fungus-spores to any comparable extent, and so we may regard these conditions as disfavouring the Larch, but not its enemy.

"Moreover, such conditions indirectly *favour* the fungus, for the tender shoots and young leaves of the Larch are apt to be cut by frosts, bruised and torn by winds, broken by snow, and injured in various ways by the inclemency of the weather, which would not injure them before the buds opened, or after the twigs and leaves were hardened and in full working order. In fact, if we could persuade our Larches to remain dormant for a month later in the spring, they would escape the evils of which they now run the gauntlet, as it were.

"It is during this period of dalliance in the opening of the buds and

the pushing of the young shoots that all kinds of small wounds are made by frost-cracks, bruises from hail and wind, breakages from the snow and storms, and, I believe, insect-injuries, and it is into these small wounds that the hyphæ of the *Peziza* penetrate.

"This view is fully borne out by the observations in the open that the young 'cankers' commonly start around the base of a dead shoot; that trees growing in damp situations are particularly apt to suffer; the prevalence of the disease in neighbourhoods and seasons where and when certain insect enemies of the Larch abound (*e.g.*, the moth *Coleophora laricella*, and the aphis *Chermes Laricis*)."

(4.) **Diseases of the Roots of Older Plants.**—The leading diseases of this class are caused by various species of *Polyporus* and of *Hysterum*, also by *Trametes radiciperda* (Fig. 309) and *Agaricus melleus* (Figs. 310 and 311), which latter two are those attacking most directly as parasitic infections without any saprophytic origin.

These two diseases are of such importance as to be worthy of a detailed description, which may again be taken from Kauschinger-Fürst's work already quoted (*Protection of Woodlands*, 1893, p. 74):—

"**The Root-Fungus** (*Trametes radiciperda*) is the most dangerous enemy of coniferous woods, occasioning red-rot and consequent interruption of the canopy of the crops, especially in the case of Spruce, Scots Pine, and Weymouth Pine. Young plants, poles, and trees are suddenly seen to die off, and soon afterwards others in their vicinity follow suit, so that not inconsiderable blanks are often formed in consequence. The snow-white receptacles or spore-producers are then to be noticed externally on the roots, and the fine mycelial threads between the scales of the bark; whilst the roots, and often the stem itself, for some distance above these are rotten, in consequence of the red-rot produced. The spread of the disease takes place in two ways, either by direct infection from the roots of neighbouring trees that may be in contact with those of the diseased stem, or else by the spores being conveyed to other individual plants by animals, especially on the furry coats of mice, voles, and the like.

"Against this latter mode of infection there are, of course, no means of adopting preventive measures; but against the former Hartig recommends the isolation of infected places by removal of the diseased stems, and the digging of ditches around the infected spots. This proposal has recently been energetically objected to, as directly tending to favour, in a high degree, the further extension of the disease, in consequence of the particularly luxuriant development of the spore-bearing receptacles of the fungus on the roots of the diseased stems that are cut through in digging the ditches.

"**The Honey-Fungus, a common edible Mushroom** (*Agaricus melleus*) is also a very common, and in many places a very dangerous, parasite in young crops of Conifers, which, however, also occurs extensively as a saprophyte on dead stools and roots of old trees, especially of Beeches. Young plantations of Conifers on soil formerly under crops of broad-leaved species—which are now so frequent in consequence of the deterioration of the soil, due to the improper treatment of the latter—appear to suffer from this fungus to a much greater extent than seems to be the case elsewhere. The blackish-brown mycelial threads (Fig. 310 *a*), that extend themselves under the surface of the soil, push their way into the bark of the roots with which they happen to come in contact, and develop themselves under it as long, white, ribbon-like filaments (Fig. 311 *a* and *b*), ultimately causing the death of both young plants and old trees. Infected plants exhibit a strong outflow of resin at the base of the stem, which penetrates and cements

[illegible] efore the true explanation was known, [illegible] canker was probably due to excessive [illegible] soil. During the autumn the sporo-

[illegible] 309.

[illegible] *ore of the Root-Fungus* (Trametes [illegible] *f natural size.*

[illegible] e their appearance on the dead plants [illegible] outh Pine—often breaking out with [illegible] large numbers around the stem of the

[illegible] 310.

[illegible] *the Honey-Fungus* (Agaricus melleus).

[illegible] omorpha subterranea) *thrown out from the* [illegible] *k of the Pine.*

[illegible] *mity of a rhizomorphous strand.*

[illegible] *nity of a rhizomorphous strand.*

[illegible] *e bark at the base of the stem of the dead Pine.*

[illegible] tacked and killed, and producing the [illegible] wind, animals, &c. On Beech stumps [illegible] n larger *pilei* as edible mushrooms.

ks of this fungus, by
characteristic features
and there in patches,
wth are attacked and
developed very good
is at once distinguish-
ike, where individual
. Such blanks, often
large patches, may
necessary for several
h broad-leaved species
e danger.
pread of the disease
with all their roots
ots by digging small
to hinder the exten-
ful collection of the

g. 311.

b

whose bark is rough,

s;[1] and when it ger-
push its rootlet into
annual zone of the
of the plant is still
g the following year
drawn from the tree
r a long period, and
by successive annual
al purposes, and look
wood-boring insects.
e excrescence caused

el more than 400 metres a
o distant regions the seeds

his subject in Sicily, where

There is very little danger indeed of trees being destroyed by disease, provided they are planted upon a soil properly adapted to their requirements. This, generally speaking, it is in the power of the intelligent forester to accomplish—by drainage in the first place, and by a judicious selection and adaptation of the different kinds of trees to the different descriptions of land; and not less important is a judicious application of systematic thinning afterwards.

It was formerly contended that a good deal of the disease seen among Scots Pine, Larch, &c., was mainly due to *diseased seed*. This explanation can hardly be made to coincide with the opinion of the great specialist on this subject, Professor R. Hartig of Munich, for with regard to the general health of crops raised from seed of rather inferior quality he has come to the conclusion (*Lehrbuch der Baumkrankheiten*, 1889, p. 16) that—

"The hereditary transference of diseases to succeeding generations is unknown in the vegetable world. The seed of plants infected with all possible sorts of diseases can, without the slightest concern, be utilised for the formation of new crops."

---

plants peculiar to northern climates are to be found alongside the indigenous plants of the country. On that island birds seek for, and disseminate, chiefly the following species :—

BIRDS.	PLANTS ON WHICH THEY FEED.
Corvidæ : Corvus frugilegus, Cornix monedula, Picus Graculus, Garrulus glandarius.	Fruits of *Prunus avium*, olive, fig, date, dwarf palm, and *Cornus Mas.*
Oriolus Galbula.	*Phillyrca variabilis, Prunus Cerasus.*
Sparrow and Chaffinch.	*Arbutus Unedo, Morus nigra* and *alba, Linum usitatissimum* and *strictum.*
Canary (*Serinus hortulanus*).	*Cruciferæ, Koenigia maritima.*
(*Emberiza Schœniculus, Rosy Ortolan*).	*Phalaris Canariensis, Setaria italica, Panicum miliaceum.*
Thrushes (*Turdis pilaris, torquatus*).	*Vaccinium Myrtillus, Myrtus communis, Rubus discolor* and *tomentosus.*
Hawfinch (*Coccothraustes vulgaris*).	*Mespilus germanica, Cratægus Azerolus.*
Turdus viscivorus.	Mistletoe.
Warblers (*Sylvia hortensis, cinerea, atricapilla, conspicillata*).	Figs—cultivated in wild form.
Nightingale (*Philomela luscinia*).	Strawberry.
Robin (*Erithacus rubicola*).	Elders, *Sambucus nigra* and *Ebulus.*
Tomtit (*Parus major*).	*Arbutus Unedo.*
Marshtits (*Parus biarmicus, pendulinus*).	*Calamagrostis, Arundo*, and *Phragmites.*
Wrens (*Regulus ignicapillus, cristatus*).	*Juniperus oxycedrus.*
Accentor alpinus and *modularis.*	Briars.
Doves (*Columba palumbus*).	Leguminosæ and Oaks.
Quail (*Coturnix, sp. sp.*).	*Phytolacca decandra.*

"Several curious examples of this method of disseminating seed are quoted. From the Botanical Garden at Palermo the small bulbs of *Oxalis cernua* were unearthed by birds, and in a short time sown in all the fields in the neighbourhood. Through the agency of wild pigeons, two Oaks (*Q. Macedonica* and *Ægilops*) are now growing in certain localities of Sicily and Sardinia.

"Seeds swallowed by birds germinate easily after having been digested. In Sicily, where many quail are killed, it is the custom to remove the contents of their stomachs and plant them in pots, by which means rare and foreign plants are often obtained."—*Indian Forester*, 1893, p. 133.

But, at the same time, the seed will be of better germinable capacity, and capable of developing a finer growth of timber, if gathered only from healthy, well-grown trees in the localities best suited for any given species of tree; and its inherent capacity for future good development will be all the greater if the seed has attained maturity under circumstances favourable to the general health, energy, and thriving of the particular species.

Injurious Insects.[1]

The subject of forest entomology is one with which the British forester is far too little acquainted. A general knowledge of the nature and habits of the numerous insects which are found injurious to plantations would be of great benefit to him, and would enable him to devise the best means at his command for their destruction. The effort of the forester, therefore, should be towards becoming familiar with the natural history of these insects, so as to enable him successfully to use such measures as will prevent the attacks of the insects upon the plantations under his charge.

Foresters need not be entomologists; but they ought to know as much of the subject as pertains to their daily work and duties in dealing with the insects injurious to forest-trees.

I. Beetles (*Coleoptera*).—This is a very extensive and important order, which includes many of the worst enemies of our woods and plantations. The name of the order, meaning *sheath-winged insects*, is derived from the insects generally having the first pair of wings horny or chitinous, so as to serve as a covering to the true wings, while the latter are not in use.

1. The Pine-Beetle (*Hylesinus piniperda*), (Figs. 312–314).[2]—This destructive little insect is only about one-sixth of an inch in length, nearly black in colour, downy, and cylindrical in form. It is very injurious among Pine plantations at nearly all stages of their growth, and until the trees are well advanced in age. Not only does it attack the young branches on the trees, but it also is found among decayed branches that are left lying in the plantations. It

[1] The attention of students may here be called to Miss Ormerod's *Injurious Insects;* to Hutchinson's *Natural History of Beetles and other Insects which infest Coniferæ, and Suggested Remedies*, in *Trans. Scot. Arbor. Socy.*, vol. vii., 1875, pp. 123–136; to Oliver's *Insects Injurious to Forest Trees* in *Trans. of High. and Agri. Soc. of Scot.*, 1877, pp. 175–200; to Somerville's *How to Combat the Attack of Injurious Insects* in *Trans. Royal Scot. Arbor. Socy.*, vol. xiii. Part I., 1891, pp. 5–20; to Blandford's article on *Insects Injurious to Coniferæ* in the *Jour. Royal Hort. Society*, vol. xiv., 1892, pp. 150–178; to the editor's translation of Kauschinger-Fürst's *Protection of Woodlands*, 1893, pp. 132–216; and to his *Studies in Forestry*, 1894, chap. xiv. pp. 306 *et seq.*

[2] For an exhaustive account of this beetle and its ravages see the *Transactions of the Highland and Agricultural Society*, 1891, pp. 31–43; full sylvicultural details will also be found in Kauschinger-Fürst, *op. cit.*, p. 146.

ed stems and branches of different
rees, doing much damage to the
sometimes also Larch.

of this species given by Somerville
32) :—

mportance.—The Pine-beetles pass
ost part in the thick bark which is
hens at the base of old Scots Pines,
ve been much infested by the insects
poses of hibernation, the beetle either
s is oftener the case, bores a passage

Fig. 314.

Shoot of Scots Pine, with a slice removed, showing the excavation caused by a Pine Beetle—two-thirds natural size.

mother and
s of forma-

this passage pursues a radical course,
far as the living cortex, little if any

in the bark of the stem at the part
etles pass the winter in the bark of
surface of the ground, but which are
Some also pass the winter in galleries
t from the ground, a few in the young
summer and strewn upon the ground
he centre of young shoots that have

ittle earlier or later, according to the
withdraw from their winter quarters,
material in which to breed. So long

as the proper conditions can be fulfilled, great discrimination and fastidiousness are displayed in the choice of a breeding-place; but as the deposition of the eggs is a matter that cannot long be delayed, it not infrequently happens that oviposition is performed in somewhat unexpected situations. The material which is preferred consists of Scots Pines that have been felled during the previous winter, or such as have been killed by fire or fungi, overthrown by wind, or broken down by snow. The fresh stools or stumps are also much sought after; but trees that are dry and partially decayed, as well as those which are in good health, are under ordinary circumstances scrupulously avoided. Thick-barked trees are much preferred to those with thin bark, so that old trees are more in request than young trees, and the lower part of a stem than the upper.

"Although the food-plant of the Pine-beetle is pre-eminently the Scots Pine, still it has been known to attack many other kinds of trees. . . .

"So long as the insect confines itself to the genus *Pinus*, it is merely following its natural instincts. Possibly it prefers *P. sylvestris* to any other species, but its occurrence in vast numbers on *P. maritima* and *P. strobus* proves that these trees are also very suitable food-plants, and indeed are probably quite as attractive to the insects as the Scots Pine. When, however, it is found on trees belonging to the genera *Picea* or *Larix*, the case is entirely altered. It is found on such trees so seldom, that it is evident there must exist a very strong reason to account for its presence there. The impelling force, I believe, to be no other than dire necessity. So long as suitable Pines can be obtained, so long will these be utilised for oviposition; but should all such trees be occupied, or should none be present, then any kind of material that is in any way suitable must be made use of. Now it is not difficult to see when such a case might occur. During the early part of last decade Scotland was visited by a series of gales of exceptional severity, which overturned great numbers of all kinds of trees, including Scots Pines. These dead and dying Pines furnished an enormous quantity of the material most suitable of all for the oviposition of Pine-beetles, which consequently increased in numbers at an almost inconceivable rate. Owing to the glutted state of the markets and to the want of labour, these blown-down trees were in many cases allowed to remain in the woods for several years, with the result that the country was perfectly overrun by an army of Pine-beetles. When, however, the fallen trees were at last cleared away, the insect found itself unable in all cases to obtain the right kind of trees in which to breed, so that it was compelled to have recourse to the Larch —a tree which, under ordinary circumstances, is quite secure from attack."

The protective measures recommended by Kauschinger-Fürst and by Blandford may be indicated in the words of the latter (*op. cit.*, p. 168) as follows:—

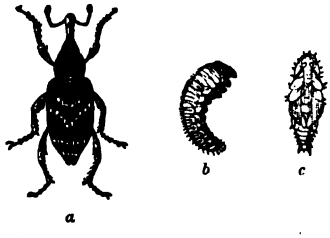
"At the beginning of winter the beetles quit the shoots, as a rule, and hibernate in moss, &c., or in small burrows made in the thick bark at the lower part of the trunk. The great treatment for this insect, as for so many others, consists in not leaving timber in the woods for the beetles to breed in—that is to say, during the months from April to July—whether it be felled in due course or destroyed by accident. If it is left till not later than the middle of June and then carted away, and the bark stripped and *burned* before the beetles have emerged, it will serve to greatly diminish the numbers of those present. For this special purpose traps may be established, which consist of standing trees ringed about February; after the beetles have entered these, and are egg-laying and breeding in the bark, they are cut down and the bark is destroyed, as mentioned above, before the larvæ hatch out. Great care must be taken to see that such bark is destroyed by

the proper time, or the whole result will be to increase the number of beetles present in the forest. All stumps and dead wood left *in situ* should be barked, and sickly trees should be cleared away before they have actually become a prey to the larvæ, unless they are to be used as tree-traps.

"Much labour has been expended in clearing up the blown-down shoots from the ground and in searching the trees for those branches which contain holes. Neither plan is commendable. The blown-down shoots are almost invariably empty, and if the latter very troublesome method be adopted, and the shoots are picked off and collected into a receptacle, it will be found, when they are carried off to be burned, that the beetles, if originally present, have all escaped."

2. **The Pine-Weevil** (*Hylobius abietis*).—This insect (Fig. 315) is about half an inch in length, black coloured, with bands of downy yellow on the back. It has a long rostrum or proboscis, and is somewhat cylindrical in form. It is fully more destructive in its habits than the beetle already referred to, as it is generally much more numerous in Pine woods. It does not confine its attacks to Pine plantations, however, although it seems to have a preference for them, for it is also found to destroy Larch and Spruce (Fig. 316), as well as several kinds of hardwoods. It is found to occur most numerously in Pine plantations formed on land that has been lately cleared of a crop of the same kind of timber—that is, where it has been replanted within four years after the clearing. Gradually as the old stumps and roots of the former crop decay, the insect becomes less numerous. If the *débris* be allowed to lie on the ground, this is sure to encourage the breeding of the insects; hence all wood should be removed in order to lessen the probability of their attacks. The following description of the habits of this insect is taken from the *Journal of Forestry*:—"The early stages of the life-history of the insect are not very clearly defined by entomologists,[1] but the female is supposed to burrow deep in the ground, and there deposit her eggs on the roots of Pines and Firs; and the passages of the larvæ appear to confirm the supposition, as they generally run upwards. The larvæ or grubs live upon dead wood, and are not

Fig. 315.



The Pine-Weevil (Hylobius abietis).

a. Imago (natural size).
b. Larva (natural size).
c. Pupa (natural size).

[1] This uncertainty has been cleared away by Von Oppen through careful observations conducted on beetles confined under circumstances resembling natural conditions as closely as possible.—"He not only proved that the beetle is endowed with a very long vital period (extending up to two years), but also that the same individual beetles are endowed with the power of re-copulation and repeated ovideposition—facts which explain in the simplest manner the simultaneous appearance of recently-developed and of older beetles, as well as of ova, larvæ, and chrysalides." (Kauschinger-Fürst, *op. cit.*, p. 152.)

[illegible] burite resorts of the [illegible] mps of felled timber, [illegible] round, and especially [illegible] permitted to accumu- [illegible] great numbers in such [illegible] males lay their eggs. [illegible] ts issue in vast num- [illegible] commit great havoc [illegible] young living growth, [illegible] isly injuring them as [illegible] t necessary to destroy

[illegible] tis) *on young Spruce plants* [illegible] *covered with bark.*

[illegible] This insect does most [illegible] k from the stems of [illegible] ound each stem; this [illegible] insects are numerous, [illegible] It also attacks old [illegible] he former much harm, [illegible] ly in old Pine, Spruce, [illegible] as it has fresh bark, [illegible] live on; it is never [illegible] has been a few years

Protective measures and exterminative remedies with regard to the Pine-weevil are thus described by Blandford (*op. cit.*, p. 161):—

"The preventive treatment of this insect consists in keeping the forest as free as possible from unbarked logs and trunks, heaps of rubbish and of sawdust, and in preventing egg-laying in the stumps of recently felled areas. This is done by barking the exposed parts of stumps, earthing them over and beating down the earth, or by washing them with an arsenical wash either of sodium arseniate, Paris-green, or London-purple. Owing to the deficient penetrating power of the two latter, which do not form a solution, but are held in suspension by the addition of dextrine or flour, the soda-salt would probably be preferable. Care should be taken to apply such remedies before egg-laying has taken place, and the spot to be protected is chiefly the junction of the wood and bark. The Paris-green or London-purple washes can be used stronger than for living plants, for which the strength should never exceed 1 ounce to 10 gallons of water. No advocacy of arsenic applied to stop insect-depredations is complete without the reminder that all buckets and other apparatus applied to that use should be kept solely for that purpose, and should be carefully destroyed when done with; no scouring should be trusted to free them from arsenic. If they are carelessly employed for other work, a serious accident will some day discredit this most valuable method of dealing with injurious insects.

"The best check of all on the propagation of this insect is to clear out the stumps, for when there are no breeding-places there can be no beetles. As these insects breed in and frequent the neighbourhood of fresh clearings, they gradually die out if there is no surrounding dead wood for egg-laying; this will be the case if the felling areas are adjusted so that adjoining sections have an interval of several years (at least four) between the periods of cutting, no section being felled close to one previously cut and planted till the new trees are well started. This can always be managed by reducing the size and increasing the number of areas; and if the forest-plan is carefully drawn out with that view, the absence of the beetle will more than compensate for the slightly increased trouble.

"*Curculio Abietis* always does most harm when areas are cut and planted in regular succession, so that every space covered with young trees adjoins one covered with fresh stumps, from which the weevils sally forth to the work of destruction.

"Young plants can be protected by surrounding the base of the stem with dry earth beaten flat with the spade, or with gas-lime or similar compounds, or by 'grease banding' the base of the stem, and in the case of Spruce, by planting with them a few Pines, which will be attacked in preference. If the area planted is clean, beetles can be prevented from entering it from outside by surrounding it with dry trenches with vertical sides about a foot deep. Into these they drop, and can be collected in large numbers, especially if brushwood be placed at the bottom.

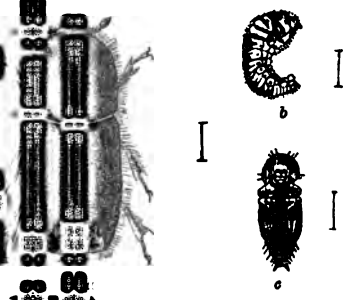
"Other methods of attracting the beetles themselves are by laying traps of Pine-bark on the ground with the inner side downwards, shoots and fresh brushwood tied in bundles, or loose logs, and by digging holes about a foot deep and filling them with fresh needles and brushwood.

"Whichever method be adopted, the traps must be visited and cleared of beetles regularly, or they will do more harm than good. This is true of all natural baits to attract insects."

3. The Eight-Toothed Spruce-Bark Beetle (*Bostrichus typographus*).—This is a small but very destructive beetle (Fig. 317), of a

Pine and Fir woods.
feeds is much similar

Fig. 317.



Toothed Spruce-Bark Beetle
trichus typographus).
o (magnified six times).
a.
a.

Pines; *B. laricis*, upon
and others.

concerning this beetle

es its exit usually during
or even towards the end
true natural home. It
ns, and soon proceeds to
trees; but, failing such,
eight above the ground,
hese the portions having
ich is somewhat large, a
6 in., mostly either pro-
hough it less frequently
galleries running closely
o to five air-holes as well
.

the right and left sides,
in a few weeks, deposits
about 100 it has been
with glucose substance.
shells, and begin to eat
sinuous larval galleries
broader and bite deeper
in. in length, each ter-
hrysalid stage is passed.
velops into the beetle, at
g darker in appearance,
weather, makes its exit
the metamorphosis from
age, but can take about

warms from the middle of June till new breed, which is also fully de- as beetles before reproducing them- able circumstances (as, for instance, ceeding at once to reproduce a third it will be seen how enormously this cumstances; but fortunately, in the turally occurs most frequently, the nnual one, or else three generations in which case the second generation

. . . . .

considerable number of beetles soon of the sap, and die rapidly in con- of the interference with the flow of occasioned by the larval galleries; beetles always make their exit from before they are quite dead, so that of such does not enable one to stay nt of reproduction.

. . . . .

e speedy removal of felled timber, ng of stems that must remain lying oods for some time, and diligent of all windfall areas to see that not develop into breeding-places for re the best preventive and protective ; whilst the felling and barking of at have been attacked, the laying sufficient number of decoy-stems in places, and the peeling and burning rk from these, constitute the most annihilative and exterminative reme- nst this dangerous enemy.

amitinus is also an eight-toothed bark- very closely resembling *B. typographus* d appearance, and in its habits and y, that it is very frequently mistaken tter. It is, however, found on the e and the Larch as well as on the f the Spruce bark-beetle on the Larch *B. amitinus*, which also appears to measures and exterminative remedies escribed for *B. typographus*."

Spotted Weevil (*Pissodes notatus*). destructive to Pine and Fir trees, nto the solid wood. It is much *Hylobius abietis*, and lives upon ne manner as that beetle. Older , as it is often found eating the with the other kinds of beetles ies of this genus also, all more or

notatus breeds among

species, *P. pini*, Bland-

atus at least has been

smaller than *Curculio*

are not toothed. They

er the bark, where they

Fig. 320.

Young Beech Seedling, whose roots have been destroyed by Melolontha vulgaris.

ung trees from three to

sed by both is to be met

which, being sickly, are

rseries so that the trees

schief to Pines planted in

ulgaris).—This is a very

cat depredations among

especially among Oak,

Sycamore, Maple, Lime, Beech, Willow, and Elm. When in the larval state, this insect does great injury to the young roots of trees, and also eats the bark of the older roots. After remaining for three to four years in this state, it becomes a full-grown beetle, and commences to eat the leaves of the trees already mentioned; but it seems to prefer the leaves of the Oak before those of any other tree. It is an insect generally well known as a destroyer of the roots and leaves of trees and shrubs (Fig. 320). There is another species of this genus—the Horse-Chestnut cockchafer (*Melolontha Hippocastani*), easily distinguishable by its being a smaller variety, and having a red thorax; it is specially destructive to the Horse-Chestnut.

The following extracts are taken from Kauschinger-Fürst's description of the cockchafer (*op. cit.*, p. 160):—

"The beetle swarms in May, or somewhat later, in raw localities. The female, after impregnation, seeks free open spaces as far as possible for ovideposition, selecting light unoccupied soil, if available, into which it burrows for a depth of 2 to 4 in., and then lays up to about thirty eggs in a cluster. Similar ovideposition takes place in several places, one female being capable of laying up to about seventy eggs in all. Whenever this reproductive function is complete, the female dies.

"About four weeks later the larvæ or grubs come out from the shell. During the first year they do not wander far from their place of birth, but seem to nourish themselves from humus or decomposing substances in the soil. When winter approaches they go deeper into the soil in order to avoid the frost, but with the return of spring ascend again nearer the surface, and now commence feeding on the roots of plants throughout the whole of the spring, summer, and autumn, after which they again hibernate as grubs. In the third spring, summer, and autumn, they once more repeat the process of gnawing and feeding on the roots of growing plants; and as during this third year the grubs are large and full-grown, it is then that their voracity and the damage they do are greatest. For the third time they hibernate as grubs, burrowing deep into the soil, and when they reascend to the surface once more in spring, they resume feeding for a short time; but about June, three years after their issue from the egg, they descend deep into the soil, in order to pass through their stage of pupal rest. The chrysalid metamorphosis takes place in a hollow scooped out of the soil, and after a few months of pupal rest the complete beetle emerges from it, being at first soft and white, but gradually hardening and deepening in colour. The beetle hibernates in the soil without once coming to the surface, and does not emerge till the following spring (May), when it makes its exit by means of a hole resembling such an one as would be made by thrusting the point of a walking-stick into the ground.

"This beetle therefore requires four years for its full normal development and generation; but in Southern Germany, in consequence of the greater warmth, the generation takes place in three years only. Hence in cold northern tracts the beetles usually swarm every fourth year, whilst in the warmer south they may be anticipated every third year. In the intervening years there are always some of these beetles to be seen flying about, but only in comparatively moderate numbers.

"As a beetle, this insect feeds on the leaves and flowers of most trees of the broad-leaved species, particularly on the foliage of Oak, Beech, Maple,

Sycamore, Horse-Chestnut, Willows, and Poplars, whilst among conifers it confines its attention mainly to the soft tufts of needles of the Larch and to the male flowers of the Pine. During years in which they swarm in large numbers, whole woods of broad-leaved trees may often be seen almost or even entirely denuded of foliage; but as they are able to replace, although perhaps only partially, their leafy crowns by means of the midsummer shoots or summer flush of leaves, the damage is practically confined merely to loss of increment for the time being.

"In forming nurseries, the vicinity of young Oak crops, and of areas stocked with broad-leaved species generally, should be avoided, as a flight of beetles almost always comes from these. The nurseries, whether temporary or permanent, should always be protected from the entry of grubs by being surrounded by a trench, whilst the spreading of a framework over each bed may prevent the female from laying her eggs in it. But the best protection consists in hanging up wooden nesting-boxes for starlings round about the nursery; for these birds take very kindly to such protection, and well repay the cost and trouble by the effective war they wage against the grubs (see Figs. 333–336).

"In undertaking annihilative measures against the beetles, we are assisted by many of their enemies, such as the hedgehog, badger, fox, marten, &c., which devour them whilst still in the ground; bats, starlings, crows, rooks, jackdaws, stannel-hawks, sparrows, &c., also destroy them in great numbers whilst swarming and laying their eggs.

"But all these co-operative remedies are practically unavailing when large swarms occur; hence endeavours should be made to decrease the numbers of the insects by collecting the beetles from trees along the edges of compartments and open spaces, especially from the lower branches, and from any Oak-coppices in the vicinity. Especially in the early morning, when the beetles sit loosely on the foliage, they can easily be brought to the ground by shaking young poles with the hand, or by tapping or knocking young stems with the padded back of a heavy axe, or by shaking the branches of larger trees by means of a pole with a hook at the end, when the beetles can be picked up off the ground by children. They can best be killed by pouring boiling water over them, or by dipping into hot water the sacks in which they have been put when collected.

"As measures for exterminating the grubs have for the most part hitherto proved unavailing, more attention has of late years been given to the collecting of the beetles, for each of the latter killed represents, or is equivalent to, the practical destruction of a large number of grubs during any of the following three years. But to be effective, it can only take place successfully in woods where broad-leaved trees occur sparsely scattered throughout a matrix of conifers, as then the chafers become attracted towards them and congregate there. Oaks, Birches, &c., are therefore often planted among conifers for the express purpose of thus acting as decoy-trees in tracts with light friable soil, where this insect is likely to swarm. Such exterminative measures should not be confined to the efforts of sylviculturists; for agriculturists are equally concerned in getting rid of the pest, and should therefore co-operate heartily in annihilating all chafers that can be found on fruit-trees in their orchards, or on timber-trees standing isolated along the fields or in hedgerows.

"The annihilation and extermination of the grubs are of course accompanied by many difficulties. This can only successfully be carried out in nurseries, where the presence of the enemy is soon betrayed by the drooping and sickening of the tender seedlings, and the grub itself can usually be collected with the hand or with a spade on one of the immediately adjacent

g-irons, and numerous other things
ves really effective in practice."

us destructor and *S. multistriatus*).
s eggs between the soft wood and
but chiefly upon the Elm. The
ut the month of July, and there
æ are hatched in the autumn, and
nner bark of the tree. This they
ring or beginning of summer, when
through the bark as perfect insects,
rds pair, the female boring into the
ore, and laying her eggs, in order
the species. The result of the
these insects is, that the cambial
the trees is so much interfered
e stems become diseased, and often
gether. Trees infested with the
ve an appearance as if the bark
riddled with shot; and very fine
ll be found either at the bottom
or upon the bark. They never
trees, but seem to prefer young
ve often been found upon unhealthy
e several other species, including
on some of the conifers; *S. intri-*
atus, on the Lime; and *S. fraxini*,
All of these insects commit their
as the *S. destructor*, by boring into
attack, and thus destroying their

lytidæ) which attack the broad-leaved
(*Bostrichus dispar*), on old Oak and
(*Hylesinus fraxini*), and the black

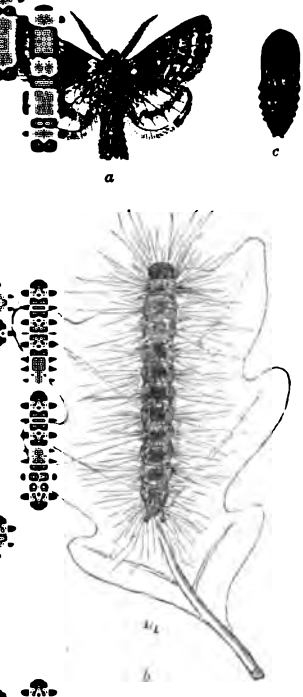
portant insects, there are numbers
t one way or another to trees and
mentioned the larvæ of a species
known as the wireworm. These
e yellow in colour. They cause

may here be remarked that a monograph on
ni) appeared in *Trans. Scot. Arbor. Socy.*, vol.

eating the roots; and
tate, it is difficult to

158) considers that—
for the nursery, and to
e it thoroughly before
ould be no difficulty in
ure, such as paring off

Fig. 322.



Processionary or Oak-Moth
ethocampa processionea),
natural size.
go (male).
rpillar at work on an Oak-leaf.
a, seen from below.

er of minute scales,
re generally supplied
e scales.

processionea).—This
larvæ constructing a
n stripes and yellow
those common cater-
f which is called the

Lackey Moth (*Gastropacha neustria*). These insects live upon the leaves of the Oak, and are often found in considerable numbers upon one tree. They derive their name from the fact of their proceeding in regular order, the one after the other, in search of food. To the same class belong the Hop-Dog (*Dasychira pudibunda*), the Brown-tail Moth (*Porthesia chrysorrhœa*), the Gipsy Moth (*Liparis dispar*), and the Buff-tip Moth (*Pygæra bucephala*), which destroy the leaves of several species of Hardwoods, also the Satin Moth (*Liparis salicis*), which does great damage, especially among Willows, as well as several others which feed on the leaves of Pines and Firs—the most important being *Gastropacha pini* and *Liparis monacha*.

The following extract from Kauschinger-Fürst (*op. cit.*, p. 202), will illustrate some of the facts connected with the Processionary or Oak-moth :—

"It is only the Oak that is attacked by this insect; but as it occurs not infrequently, the injuries inflicted can assume considerable proportions. Trees in the full enjoyment of light and air are, on the whole, most exposed to attacks from the Processionary Moth, as, for instance, standard Oaks of all descriptions, and trees near the edges of compartments. When total denudation of the foliage takes place repeatedly, so that not infrequently the mid-summer flush of leaves is destroyed as well as the spring foliage, the results are often not merely confined to temporary loss of increment, but may induce a sickly condition of growth, with 'stag-headedness,' and may ultimately lead directly to the death of the tree.

"But another danger is threatened by the long, brittle hairs, which contain some substance poisonous to both man and beast, and produce swellings and inflammation where they happen to be brought in contact with the skin. When old Oaks growing on grazing land are attacked by the caterpillars, the hairs of the latter are often swallowed by the cattle when feeding, and may occasion them a good deal of suffering.

"Protected by these long poisonous hairs, the caterpillar has few natural enemies beyond the cuckoo, and a few *Tachinæ* and *Ichneumonidæ*; but, on the other hand, the ova are well-nigh decimated during the winter by tomtits, woodpeckers, &c.

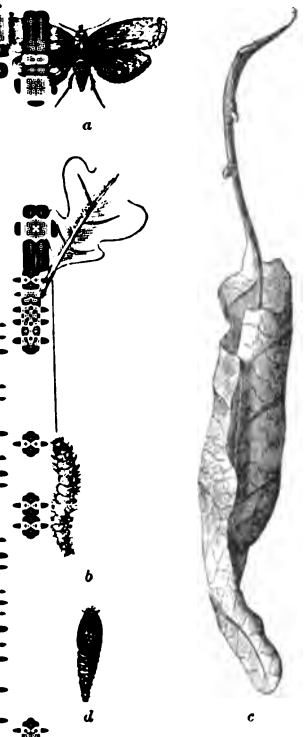
"The best annihilative measure that can be adopted against this insect consists in the removal and crushing or burning of the nests containing the caterpillars and chrysalides; when these latter are high up the stem, ladders will either be necessary, or else a pole with a knob of tow dipped in petroleum, and then lighted so as to set fire to the nest. For nests that are too high up for this method to be successful, Altum recommends the use of the gun with a large charge of very small shot and a small charge of gunpowder, so as to knock the nest to pieces.

"Whether the caterpillars be collected first or directly destroyed, the greatest caution should be taken to ensure that the woodmen should not have their health injured in any way by the poisonous hairs. Thick gloves, and an adequate protection, as, for instance, a damp sponge over both mouth and nostrils, are necessary; and if the exterminative measures can take place during wet weather, so much the better, as the hairs are not only less brittle then, but are also less apt to float about in the air.

"In areas infested for the time being by these caterpillars, the woods should, for obvious reasons, be closed to the collection of berries, the cutting of grass, and the herding of cattle."

rous woods in Germany
th (*Gastropacha Pini*)
wlet-moths (*Noctuidæ*),
pers (*Geometridæ*), the
llers (*Tortricidæ*), the
Tortrix (*R. turionana*),
Spruce-shoot Tortrix

Fig. 323.



e Oak-Leaf Roller (Tortrix viridana)—*natural size.*
ago or fully developed moth.
erpillar spinning itself down means of a gossamer-like fila-ent.
lled-up Oak-leaf in which the hrysalid stage is passed.
rysalis.

the one now described.

to revise the thickets
destroy any buds that

).—The caterpillar of
s upon the leaves of

by Loudon:—"The moth varies in
to 13 lines; the anterior wings are
n in front, and the posterior wings
this moth rolls up the Oak-leaves
to form a very commodious retreat
resides, the centre of the roll being
le to that of the body of the insect,
little packets of silk attached to the

Fig. 325.

Exhibiting the Larch-Mining Moth at work, and the nature of the damage done by it.

oining part of the roll." In many
nches almost entirely of their foliage;
hich they live upon in such a way
d to prevent them performing their
healthy manner.

the middle till the end of June, when
in small clusters on the buds then being
of Oaks. The tiny caterpillars make
ng spring, when they attack the buds,
the beginning of June proceed to enter

the chrysalid stage in leaves rolled together, in fissures of the bark, &c., from which they emerge as imagines after a pupal rest of about three weeks; hence its generation is simple and annual.

"In consequence of the ova being deposited on the buds and young twigs, the feeding of the caterpillars always begins near the top of the leafy crown, and gradually works its way downwards, often resulting in total denudation of the foliage, which can only be replaced when the midsummer flush of leaves takes place." (Kauschinger-Fürst, *op. cit.*, p. 211.)

4. **The Larch-Mining Moth** (*Coleophora laricella*) (Figs. 324, 325) is an insect closely allied to the *Tortricidæ*, and, along with the Grey Larch-twister (*Grapholitha pinicolana*), is undoubtedly one of the *predisposing causes* to which a good deal of the Larch disease occasioned by the fungus *Peziza Willkommii* is attributable. So long as there are no wounds in the outer layer, cuticle, periderm, or epidermis of the foliage, shoots, and bark, fungoid spores coming in contact with plants, and germinating by throwing out their *hyphæ*, can only develop normally when they are able to infect the plant by effecting an entrance into its living tissue, so as to find the requirements necessary to their growth as parasites. When once the foliage of Larch is damaged by hail, or by *Coleophora laricella* (which appeared in enormous swarms in some parts of Britain during the warm dry spring of 1893, and especially in Gloucestershire), or by *Grapholitha pinicolana*, or by the Larch-bug or aphis (*Chernies laricis*), then the trees are not only predisposed to disease by the disturbance created within the organism, but doors are thereby opened for the entrance of the *Peziza* spores (see pp. 301, 304). Concerning the Larch-miner, Blandford (*op. cit.*, p. 165) writes as follows:—

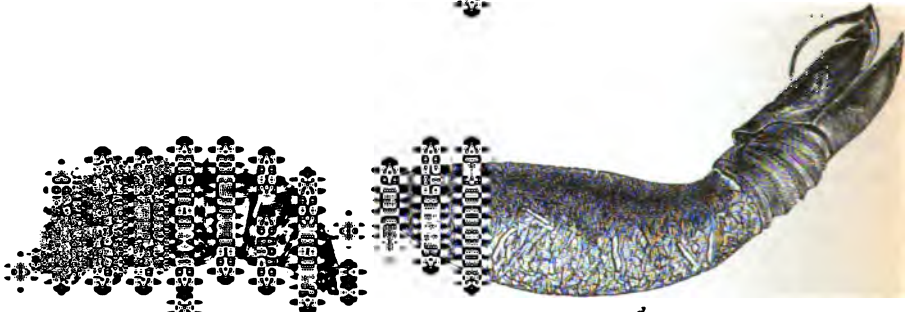
"A special form of injury is that inflicted on Larch-needles by the larvæ of a tiny moth, *Coleophora laricella*, which lays its eggs at the end of June on the needles of the lower branches of Larches about 10 to 14 years old. The caterpillar mines into and feeds upon the interior of the needle, which becomes dry, yellow, and twisted; it then bites off the tip and detaches the needle about its middle, so as to form a tube in which it lives and passes the winter, concealed in a crack or under a bark-scale. In the spring it feeds on the new needles, and enlarges its tube by spinning a fresh needle along its side, biting it off and hollowing out the adjacent surfaces; in this tube it changes to a pupa, and ultimately to a moth. This insect is common in many English Larch plantations, whose foliage, when the attack is bad, has a dull withered look which is very conspicuous; it does not kill the tree, but keeps it year after year in an unhealthy condition.

"Practical treatment is difficult; picking off the injured shoots is very troublesome, and the only successful plan is to remove badly-attacked trees, and burn the foliage before the moth flies in June. It is best prevented by growing Larch in a suitable mixture, and not in pure woods. Special importance attaches to this and other Larch-feeding insects because the wounds which they make probably serve as a nidus for the spores of Larch canker."

5. **The Goat-Moth** (*Cossus ligniperda*).—This large moth (Fig. 326), which is commonly known by the name of "Augur-worm" in Scotland, is one of the worst of enemies to several species of broad-leaved trees. It attacks Elm, Oak, Willow, Poplar, Ash, Alder, Walnut, Beech, and Lime. The larvæ drill holes through the bark and into the timber, and finally cause a disturbance in the performance of the cambial duties.

[illegible] the attacks of the insect not infre- [illegible] They may be often found boring [illegible] and Poplar, as they prefer soft-

[illegible] 6.



d

[illegible] niperda)—*natural size.*

[illegible] *(c).*

[illegible] *ch the chrysalid stage is passed.*

[illegible] as the trees become riddled with [illegible] name of "**goat-moth**" from the [illegible] pillar emits; this arises from a

secretion emitted from its mouth, which is supposed to be for the purpose of softening the wood as it goes along. The goat-moth is thus described by Loudon:—"About 3 inches in expanse; fore-wings rich brown, varied and mottled with darker markings, crossing the wings in waved lines; the hinder wings somewhat similarly marked, but of a dull pale brown. The caterpillar is flesh-coloured in its early stage, with a black head, and broad dull red stripe down the back; the colouring becomes more definitely red on the back and orange at the sides as the caterpillar gets towards full growth, when it is as much as 3 or 4 inches in length."

The moth swarms in June and July, when the ova are deposited, to a total of about 25, in the bark-fissures of Oak, Elm, and most Softwoods. In July the caterpillars appear and continue boring in the wood till the May of the second year afterwards, the generation being biennial; they do great damage to the timber technically.

6. The Wood-Leopard Moth (*Zeuzera Æsculi*).—This insect is smaller than the goat-moth, being about 2½ in. in expanse. The wings are almost transparent, of a whitish colour, and with dark spots upon them, those on the hinder ones being less noticeable than the spots upon the fore-wings. The body of the insect is grey, and upon the thorax are six black spots. The name of the moth is evidently derived from the many spots which are upon the wings and the thorax or second segment of the insect. The larva is of a yellowish-white colour, dotted with black spots, while the head is dark-coloured. The destructive habits of the wood-leopard moth are much the same as those of the goat-moth, the caterpillar boring its way into the trunks of the Oak, Birch, Horse-Chestnut, Beech, Walnut, Lime, Willow, Poplar, Elm, Alder, and Laburnum, as well as Pear and Apple trees. The egg is laid upon the bark, and the young larva enters the wood by a small hole, making its way through the centre of the wood, and forming a regular cavity as it goes along. It is said to remain for at least two years in the larval state, shortly after which it comes out as a perfect moth. The eggs are laid in the autumn, and the caterpillar is of full size about June of the year following.

The caterpillar appears in August, eats in the sapwood for the first summer, but then proceeds deeper into the wood, boring upwards into the stem; in June of the second year it returns to near the bark, in order to enter the pupal state, and thus complete its biennial generation.

Several other moths perforate the branches of some trees in a similar way to these two above described. Such are the Red-belted Clearwing (*Sesia culiciformis*), which attacks the Birch; the Red-tipped Clearwing (*S. formicæformis*), common in Osier-beds; the Hornet Clearwings (*S. bombiciformis, S. apiformis,* and *S. tipuliformis*), living

upon different species of deciduous trees. Besides these, many other moths and butterflies are injurious to the leaves of trees and shrubs; but for detailed information concerning these the previously named references should be consulted.

III. **Membrane-Winged Insects** (*Hymenoptera*).—The distinguishing characteristics of this order are, among others, that the anterior and posterior wings are hooked together during flight, and that the insects have an appendage at the tail in the form of a sting or of an ovipositor. Numbers of them come under the attention of the forester, as committing destruction upon many kinds of trees. Although divided into groups, differing from one another in some points, yet for the present purpose only a few species, particularly destructive among forest-trees, can be referred to even in a brief manner.

1. **The Pine-Sawfly** (*Lophyrus Pini*).—This is one of the most destructive of the Pine insects throughout Britain (see Fig. 327). It chiefly attacks the leaves of the Scots Pine, devouring them down to the bottom of the leaf, and completely disfiguring the branches. The damage is done by the larvæ, numbers of which appear on one branch, and then proceed to others until the tree is entirely defoliated. They begin to appear upon the trees about the month of May, and continue until some time in September. Their power of reproduction is wonderful; and were it not for birds which feed upon them, and for fungoid diseases with which they become infected, they would soon be the means of entirely destroying many trees, and even plantations. They very often attack young plantations, and frequently confine themselves to one spot at a time; they are also found upon older trees, however, eating the young leaves in the same manner. There are several species of sawflies injurious to vegetation, but the one mentioned commits more mischief than any of the others. The larvæ of the sawflies are easily distinguished from those of the moths by their feet numbering from ten to sixteen. The ovipositor of the female insect is used as a saw or file, with which she makes small holes in the branches for the purpose of depositing her eggs, hence the name "**sawfly**."

The following is the description of the Pine-sawfly given by Blandford (*op. cit.*, p. 163):—

"The females in late spring cut a longitudinal slit in a Pine-needle, and lay in it from 10 to 20 eggs, repeating the process on the adjoining needles till about 120 eggs have been deposited. The larvæ hatch in a fortnight or rather more, and live together in small companies on Pine-shoots, feeding on the needles, from the midribs of which they strip away the sides. They fortunately confine their attacks to the older needles, and not to the young ones of the first year. Towards the end of their two months' life they devour the needles completely, disregarding the midrib. They are cater-

in colour, being usually
a blackish head and a
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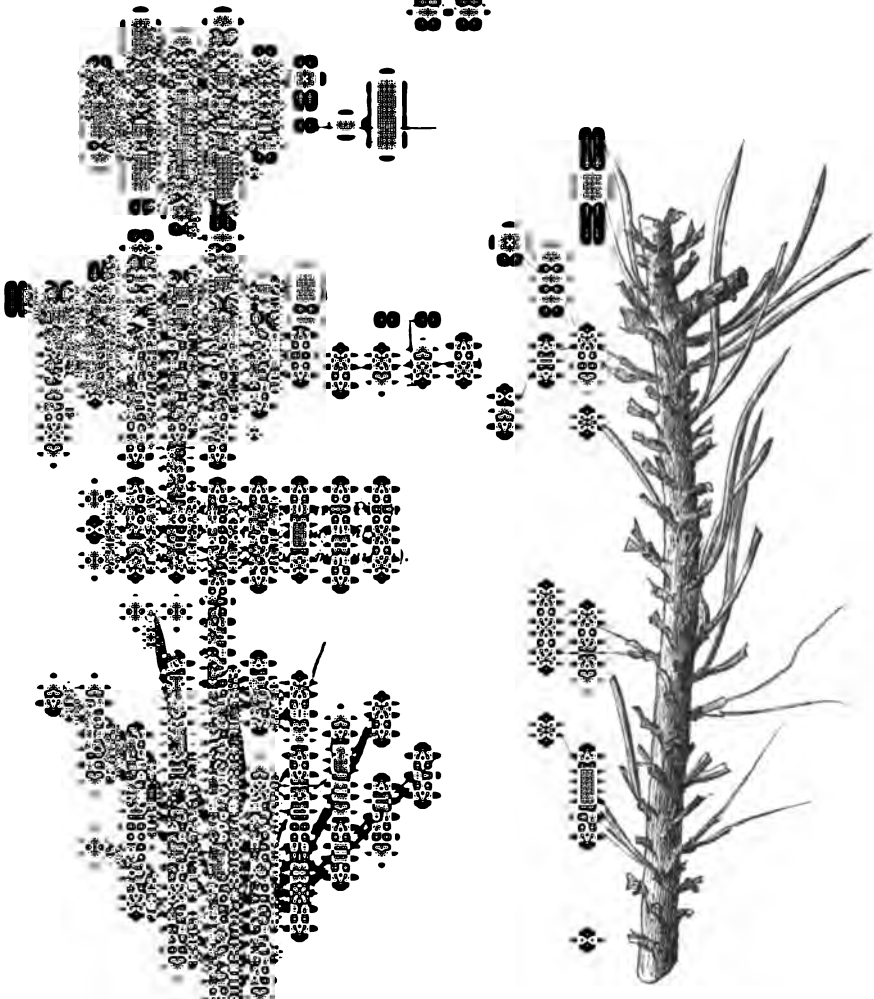
at the foot of the tree,
les on the ground. In



damage done to a twig of the
ine by the Pine-Sawfly (natu-

d brood of flies appears
d in the autumn their
year, which are then
ut the winter in their
three weeks before the

flight-time. The winter period is always passed in the cocoon by the summer larvæ if there is no autumn brood.

"The larvæ can be destroyed by shaking them down on to cloths and there killing them, or they may be crushed *in situ*, by grasping them with a gloved hand or a wad of tow, or with a metal implement like a pair of scissors, with two large flat blades meeting face to face.

"They can also be killed by spraying with a solution of hellebore, or sprinkling it on as a powder, but better results would be got by the use of Paris-green, as for fruit-trees. The expense of this treatment is not great; low fruit-trees are sprayed for about 7s. to 10s. per acre, exclusive of the prime cost of the machine used. A hand-machine, which will spray trees up to 14 ft. in height, can be bought for less than £3; it requires two men to use it. Apparatus of this sort should find its way into every large nursery where occasional trouble from defoliating or other insects is experienced. The objections to the use of arsenic on fruit-trees do not apply here, except when there is risk of injury to game.

"The pupæ of *Lophyrus* can be destroyed by raking up the brushwood and upper layer of needles under the infected trees in the winter with the contained cocoon, and conveying to a spot where it may be safely burned. A very serious objection to this plan is that it deprives the soil of its natural surface-covering of needles, and if persisted in for a long time it will injure the health of the trees. It should not be resorted to without good cause, and when other remedies cannot be adopted. The removal of brushwood, &c., as opposed to this covering of needles, is always valuable for the prevention of insects."

2. The Giant Wood-Wasp (*Sirex gigas*).—This is one of the Pine-boring insects, and in some parts of the country becomes very destructive among coniferous trees. They are very large, and during flight make a humming noise. The following description, taken from the *Journal of Forestry*, will give an idea of this insect:—"The specimens sent us are all females, and are easily distinguished from the males, being fully one-third larger, of a darker colour, and furnished on the under side of the abdomen, near the middle, with a strong black ovipositor, composed of two semi-cylindrical members, with which it bores holes through the bark to deposit its eggs on the wood. The male is smaller, lighter in colour, and without the ovipositor, having a perfectly smooth cylindrical abdomen. After pairing, the female bores a hole for each egg in the bark of the stem of the tree with her long ovipositor. In about seven weeks after the eggs are laid, the larvæ have attained their full size, and are from 1½ to 2 in. long; the tail-joint is thick, ending in a short point, and of a whitish-yellow colour. They then generally gnaw their way deep into the heart of the wood, forming a cavity at the depth of 6 in. more or less, where they undergo transformation to the pupal state, covered with a thin transparent skin. In this state they remain for two years or longer; in fact, instances are on record of the perfect insect only making its appearance some years after the trees had been cut down, and the timber employed in house-building

this insect seems to
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n in a decayed state,
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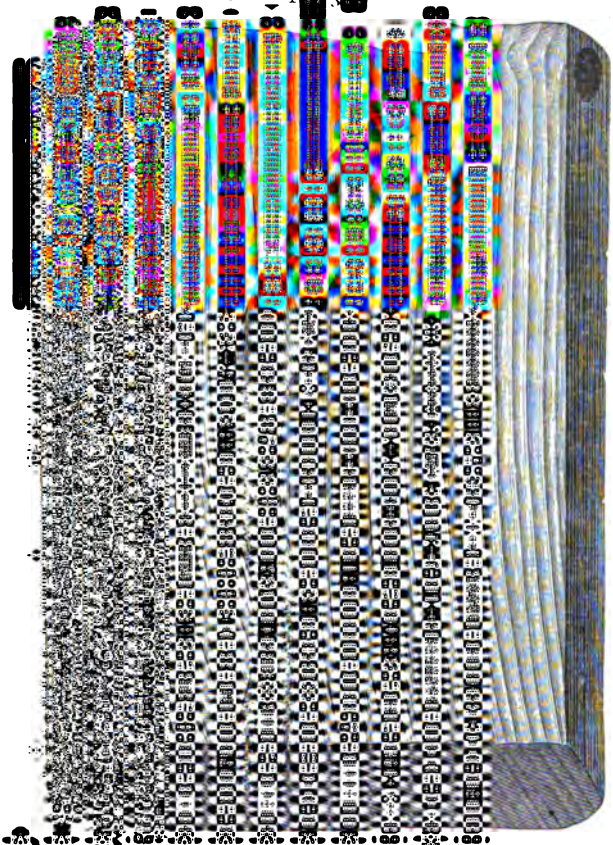

Pine—natural size.
dust (B).

328) and *S. spectrum*)
boring into them in

generation is always at
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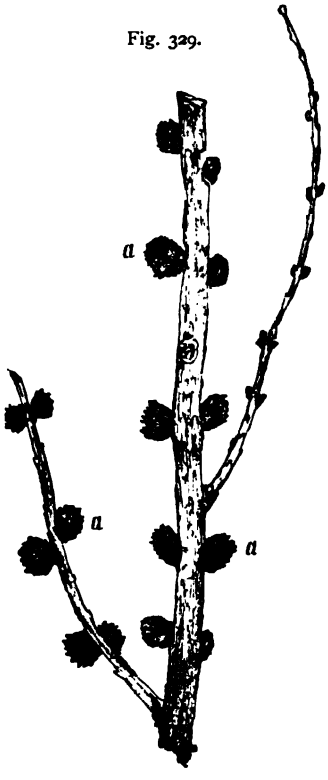
n prepared and worked
r annihilative measure
but without delay any
s clean as possible by
t, *op. cit.*, pp. 189, 190.)

3. The Oak-Gall Wasp (*Cynips querci*).—The family *Cynipidæ* includes a number of peculiar insects, chiefly inhabiting the different species of Oaks. They are all provided with an ovipositor, which is entirely concealed except at the extremity. With this instrument holes are bored in the leaves or small branches of the tree, and the eggs deposited in them, in much the same way as is done by the sawfly. Some time afterwards, what are known as "oak-galls" are formed round the eggs, so as to enclose them; and when the young larva is formed, it is enclosed within the middle of the gall, where it remains until it eats its way out as a perfect insect. The species here mentioned particularly is that which is common upon our Oak-trees, and is too well known to need any description in detail. It is found nearly all over the country, wherever there are Oak plantations.

Fig. 329.



Galls produced on a twig by the Larch Gall-Wasp (Cecidomyia Kellneri)—*natural size.*

In addition to the above, the chief gall-wasps are the *Cynips fecundatrix*, which causes the clusters of wooden excrescences like hop-fruits or cones at the points of Oak-twigs, and *C. terminalis*, which produces the large red "roses" or spongy galls at the tips of Oak-twigs.

IV. Flies and Midges (*Diptera*).—Somewhat similar malformations to those occasioned by gall-wasps are caused on Beech foliage by *Cecidomyia fagi*, and on Willows and Osiers by *C. salicis* and *C. saliciperda*.

"During May the ova are deposited in a long string on the back of young shoots and stems of Willows (chiefly on *Salix alba*, *S. viminalis*, and *S. acutifolia*), and in June the reddish-yellow maggots work their way into the inside. Here, from July to the following April, they bore irregular vertical galleries, at the same time causing the formation of spindle-shaped swellings, which ultimately become scabby from the bursting of the bark, and within which the chrysalis remains. When it is not convenient to cut out the shoots or stems infested, the swellings should be smeared with patent tar." (Hess, *Forstschutz*, vol. ii., 1890, p. 98.)

Conifers are also liable to be slightly attacked by the gall-wasps *Cecidomyia brachyntera* chiefly on Pine, *C. piceæ* and *C. abietiperda* chiefly on Spruce, and *C. Kellneri* (Fig. 329) on Larch.

this order of insects
erest to the forester,

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ey extract from the
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Fig. 330.

mage done by the Larch-Bug or arch Aphis (Chermes laricis) *—natural size.*

The lice at work sucking out e sap from the leaves, which onsequently get bent at these laces.

trees and plantations,
iving ones. Attacks
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170) says :—
pass the winter under
Abietis ; they also are
black colour, and have

they penetrate the needles to feed
pril they lay forty to fifty eggs on
er themselves over the needles, and
rst very minute and blackish, they
th a whitish woolly down exuding
oes the appearance of being covered
About June they acquire wings and
ods are produced till the autumn.
occurs on Larches of all ages, being
haps, most frequently on trees of 10
s old. It not seldom affects young
nurseries, and may there be very
e."

he *Cynipidæ*, and like many kinds of
e of the *Aphidæ* have the power of
g themselves parthenogenetically, *i.e.*,
xual intercourse during each stage of
The Larch-bug has been recently
stand in change of generation with
aphis (*Chermes abietis*), which pro-
cone-like excrescences so common at
f Spruce twigs (Fig. 58 *b*, vol. i. p.
ig. 331). Concerning the latter insect,
s obtains a double interest for the
he following remarks are made by
n the *Gardeners' Chronicle*, 1893, p.

Spruce-Gall Aphis (*Chermes abietis*)
undant all over England, and this
particular its depredations have been
o an alarming extent. When abun-
general health of the trees is seriously
hile in every case crippling and dis-
the branches is brought about by
dreaded insect. Having passed the
crevices of the bark, the Chermes
d wingless insects, and attach them-
of the Spruce. A mass of eggs is
two twigs meet, the larvæ of which,
eir beaks, this causing the swelling
esembles a small Fir cone."

is another species of this family,
ges, and also is to be found in
s. This insect is the cause of
imilar description to that done by

he following (Kauschinger-Fürst, *op.*

a ulmi) produces the small club-like
e upper side of the leaves of the Elm,
ometimes covered. The **Elm-blister**

Aphis (*Schizoneura lanuginosa*) causes the large hairy galls that occur on the tips of the shoots and on the foliage of Elms; during the summer these blisters contain an indiarubber-like fluid in which the lice live from June till August. At first the galls are green and red, but turn brown as they harden and dry. The **Beech Aphis** (*Chermes fagi*) and the **Ash Aphis** (*Chermes fraxini*) produce cankerous-like spots on the bark of these trees."

2. The Blight Insects (*Coccidæ*).—It is to this family that the **Scale**, so common upon different species of our forest-trees, belongs. **Scale** (*Coccus*) is a small white insect found clinging to the bark of some species. In forest-trees it is most frequently found upon the Ash while in a young state, especially upon young Ash-trees which have received an injudicious and too sudden thinning, or which are growing upon a light gravelly soil that is not congenial to their healthy growth. In this latter case, where the soil or situation is at fault, the trees affected will never be likely to thrive; but where the trees affected appear to have been injured by too severe thinning, the case is very different. These may be recovered by scraping off the outer bark with the scale, and maintaining the trees in better canopy in future. The scale is easily distinguished by the appearance of the insect upon the surface of the bark. It presents itself as very numerous small white spots, like those on the bark of the Birch; and if the observer take a stone and draw it roughly along the tree, he will kill many of the insects, and their blood will give a red tinge to the bark.

A black variety of Scale is produced on the bark of young Spruce twigs by the *Coccus racemosus*.

VI. Straight-Winged Insects (*Orthoptera*).—The most important insect belonging to this order is the mole-cricket (Fig. 332), which belongs to the family of the Crickets (*Gryllidæ*).

The Mole-Cricket (*Gryllus gryllotalpa*) has only an imperfect metamorphosis. The wingless larva closely resembles the complete insect; whilst the chrysalis only differs from the latter in having rudimentary wings, not strong enough to fly with. During all these three stages of development the insect crawls about and continues to feed. This can be a very destructive pest in nurseries. The following description of it is given by Kauschinger-Fürst (*op. cit.*, p. 190):—

"The pairing time is in June, when each sex entices the other by means of a chirping under ground. After impregnation the female deposits her ova, up to the number of about 200, and in size about as large as a grain of hempseed, inside a nest formed by a hollow clump of earth about the size of a fist, cemented with a kind of slime, and lying about 3 to 4 in. below the surface of the soil.

"After about two or three weeks the larvæ make their appearance in July, being at first of a whitish colour, but becoming darker later on, and soon wander throughout the soil in search of food. After hibernating under the surface of the soil, and making several changes of skin, they develop

ing. It is well worthy of note that
or the opening of the nest containing
actually devours a large number of

or the most part animal, and in this
ful. But in its search for cockchafer
many seedlings in nurseries, in the
hese at last become as large as could
t bites through all roots that oppose
passage, and thus causes seedlings
transplants to wither and die off.
is damage may at times become very
siderable, especially in Pine and
ruce seed-beds.

"The methods of endeavouring to
erminate the mole-cricket comprise
following:—

"1. The seeking out of nests, which
y be tracked by the confluence or
nverging of the runs, that dip down
ver into the ground when they ap-
oach the nest. Although the runs are
arked by air-holes in the soil, which
ok as if they had been made by stick-
g one's finger into the ground, and
the withering and dying off of the
edlings, yet it is by no means alto-
ther an easy matter to find out the
sts.

"2. The planting-out of ordinary
wer-pots, the holes in the bottom of
hich have been plugged up with cork,
out 6 ft. apart, and the stretching of
ces of wood, like laths, across from
t to pot, so that when the crickets
e wandering about at nightfall during
e pairing-time they cannot pass, but
e forced to go along the edge of the
h, and finally tumble into the pots.

"3. The killing of the mole-crickets
en they are calling to each other
e done by cautiously approaching the
then suddenly dislodging it in a clod

ul of petroleum, oil, or tar into the
distinguishable after rain, and then
full. As soon as the cricket gets
ascends for fresh air, and then can

order of the *Arachnida*, which
te *Arthropoda* (including scorpions,
ed among the *Insecta* by Linnæus,
s group of insects there is at least

one species which often infests the bark and leaves of many trees, the **Red Spider** (*Acarus telarius*), a minute insect found under the bark and upon the leaves of Elm, Poplar, Lime, Spruce, and Scots Pine. It causes the leaves of trees attacked to turn brown, and generally to fall off altogether; so that in this way many trees are weakened and their bark injured by these insects. They abound chiefly in dry warm weather, and are seldom to be found during a wet season.

Prevention of Attacks by Noxious Insects.—The insects above mentioned include most of the kinds of insects generally destructive in British woodlands and nurseries. When once the more injurious classes of insects swarm in large numbers, they reproduce themselves so rapidly that in many cases there are really no practical remedies available for their extermination. All the more importance, therefore, attaches to preventive measures, in order that the numerical increase of noxious species may be checked. And in order to effect this desirable result it is necessary that foresters should be well acquainted with the life-history of the different classes of insects, their appearance, and the nature of the damage they do; for, until foresters are properly acquainted with these matters, they cannot be in a good position to prevent the attacks of injurious insects.

Sylvicultural experience on the Continent has shown that whenever any great insect calamity has arisen and continued for two or three years in succession, the later generations of the insects are of a weakly constitution, and die off rapidly in consequence of parasitic fungoid diseases with which the larvæ become infected. This is more particularly the case with moths like the Pine-moth (*Gastropacha Pini*) and the Spruce-moth (*Liparis monacha*), whose larvæ die off about the third year, and the attacks cease almost as suddenly as they began.

It may be noticed here that, where the land is in a proper condition for the healthy growth of trees, and where the kinds cultivated are properly suited to the land, very little harm has hitherto in Britain been found to arise from insect attacks on them. It is generally in wet and undrained districts that insects are engendered and appear in large numbers; and it is therefore in such that they are found to do most damage, as the trees themselves cannot be in the most vigorous and robust health. On dry lands they are never found numerous in this country; and consequently on such they are seldom or never found hurtful to trees, at least to anything like an important extent.

All dead branches and the *débris* of thinnings should in all cases be removed from woods and plantations, and should not under any pretext be allowed to lie upon the ground for any length of time after they are cut off from the fallen trees. In plantations fallen branches and the remains of a course of thinning are often left lying to rot upon

the ground without any attention being paid to gathering them up or burning them. Such a system cannot be too much condemned, as it is not only opposed to good management, but such dead and decaying branches are also just the breeding-places where most of the dangerous insect enemies of forest-trees are generated. By removing these branches, and either burning them or converting them into faggots for firewood, a great benefit to the plantation will be the result. In thus keeping all plantations free from small material of this kind, it will be found that they will not be liable to be infested with injurious insects. The after-health of the growing crop will fully compensate for any expense that may be incurred in the operation of clearing and destroying the branches, even although the latter can be put to no profitable use. All foresters, therefore, who wish to have the woods under their charge in a good state of health and as free from the ravages of insects as possible, should use every possible means to have all small poles, branches, and brushwood cleared away as soon after thinning as possible.

Where any of the beetles or moths can be easily collected, they should be picked off the trees and destroyed. This is no doubt a tedious and expensive process, but where the area infested is not large, it will often be found to be a very good remedy. A good plan is to use an averuncator (see p. 168) for cutting off any small twigs that are covered with insects or their larvæ.

The Pine-sawfly has been destroyed by sprinkling naphtha upon the larvæ by a brush, and by this means that insect may sometimes be easily cleared from a small ornamental plantation. For destroying those moths which bore into the trunks of the trees, like the leopard-moth, for example, the only way is to thrust a piece of sharp wire into the hole and pick out the caterpillar, or to blow tobacco-smoke into the hole, which has the effect of disturbing the repose of the larva and bringing him out; but these are remedies that can only be employed on a very small scale, in ornamental woods and in the case of avenue and park trees.

When large plantations and woods are infested, there is often really no remedy except keeping the ground clear and hand-picking as many of the caterpillars as possible.

It cannot, however, be too strongly urged that all birds which feed upon insects should be preserved, as they materially assist in keeping down such vermin. Among the birds which are of most use to the forester in this way, special mention may be made of the chaffinch, goldfinch, greenfinch, woodpecker, titmouse, golden-crested regulus, wren, wagtail, cuckoo, starling, sparrow, flycatcher, robin, and some others. It will be to the forester's interest to preserve these, even although some of them show a special partiality for seeds.

Continental Methods of Prevention and Extermination.—In the vast forests throughout Central Europe, the dangers threatened to woodland growth by insect enemies assume proportions absolutely unknown in Britain. The only similar case that can even be mentioned in slight comparison with some of these disasters, occasioned chiefly by moths like Pine and Spruce moths and bark-beetles of the *Bostrichini* and *Hylesinini*, is the Larch disease in Britain; and its effects differ essentially from those of insect attacks in which the trees are killed in hundreds of thousands.

The best **preventive measures** have in Germany been found to consist in careful thinning of the woods. Whenever dominated or suppressed stems fall into a sickly state of growth, they become predisposed to disturbing influences such as insect attacks, and towards liability to infection with parasitic fungoid diseases; hence they soon develop into breeding-centres from which the evils spread around in all directions. In the case of the Spruce-moth (*Liparis monacha*), for example—a rare insect often difficult to procure specimens of for entomological collections, but which has recently been frequently noted in British woods—the attacks are for one or two years so slight as almost to be unnoticeable; and then all at once the caterpillars appear in enormous numbers, devouring all the foliage of Spruce and Pines, and devastating the areas infested. The only possible preventive measures are those of the following sylvicultural nature:—

1. Selection of suitable species of trees for the given soil and situation.
2. Formation of mixed woods in preference to pure forests.
3. Careful thinning and tending of the woods, and immediate removal of sickly stems.
4. Frequent examinations of the woods and observations as to the state of the crops.
5. Grubbing up of stumps of conifers, if possible, before replanting the area.
6. Making falls of coniferous timber between spring and autumn, so as to enable the logs to be barked. Where felling in winter is practised, a few stems here and there should be ringed and left standing as decoy stems, in order to attract the bark-beetles. These should then be felled and barked, and the bark should be burned, in order to prevent the ova and larvæ developing into mature insects and multiplying.
7. Speedy removal of all thinnings and falls of timber, and clearance of the branches and brushwood.

It is most probably owing to the fact that our British woodlands are mostly mixed woods, and not pure crops of one particular species, that insect attacks have not in the past been very injurious. But with the tendency to form pure crops, from the erroneous idea that they are probably on the whole more remunerative than mixed crops, danger from insects must increase. The editor's views on this subject are contained in the following extract from *Studies in Forestry*, chap. v.:—

"6. **Experience has shown that mixed forests are much less exposed than pure forests to danger from external causes, whether of organic or inorganic origin.**— . . . When grown along with deciduous broad-leaved species, conifers of all kinds suffer also much less from storms, fire, damage from snow, ice, or frozen sleet, insects, and fungoid diseases than when grown in pure crops, or even in mixed crops of conifers only. Associated along with broad-leaved trees, the conifers generally attain a better development than under other circumstances, so that they are less

liable to the attacks of insect enemies; these latter are also better kept in check by the birds that feed on them, and which are more numerous among deciduous trees than conifers. Even should attacks of insects occur, they seldom spread widely over all species, and never necessitate total clearance of the whole crop, as so often unfortunately happens in the case of pure woods of Spruce and Scots Pine. . . .

"But it is perhaps more with regard to injuries caused by insect enemies than in any other way that the beneficial effects of the formation of mixed crops may be judged of as far as Spruce and Scots Pine are concerned. Simultaneously with the disappearance of the natural mixed crops, which can be proved to have formed the chief portion of the soil-covering of wooded areas throughout Germany during the first quarter of the present century, and with the formation of extensive pure forests of coniferous species, the damage done by insect enemies has increased enormously, and has on many occasions during the past half-century risen to the height of calamities, sometimes of national importance. Thus, in speaking of the ravages caused by the Black Arches, "Nun," or Spruce-moth (*Liparis monacha*), which—together with the bark-beetles (*Bostrichini* and *Hylesinini*) that followed in its wake attacking the sickly stems left alive—between 1853 and 1862 devastated the coniferous forests of Eastern Prussia and Western Russia over about 7000 geographical square miles, and necessitated the felling of over 420,000,000 cubic ft. of timber, Hess (*Der Forstschutz*, vol. i., 1887, p. 355) recommends, as the first measure of prevention, *avoidance of the formation of pure forests of Spruce or Scots Pine; formation of mixed crops of suitable species.* This same insect has also recently in Southern Bavaria (1889–91) necessitated the clearance of 40,000 acres, mostly of pure Spruce, and has involved a special outlay during the present year (1892) of £75,000 in order to prevent the continuation of the attacks in the State forests alone (see the *Transactions of the Highland and Agricultural Society*, 1893). . . .

"That forests of broad-leaved species are not exposed in anything like so great measure to devastating attacks of insects is a well-known matter of experience. Even after crops may have been stripped of their spring flush of leaves, as sometimes takes place with the Oak when there are swarms of the caterpillars of *Gastropacha processionea*, the injury is not of a permanent nature, owing to the much larger reserves of starchy and nitrogenous matter contained in broad-leaved kinds of trees, and the stronger reproductive and recuperative capacity with which they are thereby naturally endowed.

"By admixture of broad-leaved species, and particularly of Beech or Hornbeam, along with conifers, the danger of attacks from noxious insects can be materially diminished without in any way impairing the other advantages derivable from the formation of mixed crops. Thus, Danckelmann (*Zeitschrift für Forst- und Jagdwesen*, 1881, p. 1) states, that woods which consisted of four-fifths Scots Pine and one-fifth Beech or Hornbeam practically did not suffer at all in Prussia from any of the insect calamities occasioned by *Bombycidæ* between 1860 and 1880, whilst the pure Pine woods suffered severely.

"The beneficial effect of mixed crops in obviating extensive injuries from insect enemies is perhaps about the only point concerning which German sylviculturists are absolutely unanimous."

In referring to the Pine-beetle and the Pine-weevil, Blandford's descriptions of preventive and exterminative measures have already been given; but, as information on such subjects is not always within convenient reach, it may perhaps be desirable to indicate the methods still further by means of other extracts.

Thus, what Somerville (*Trans. of High. and Agri. Society Scot.*, 1891, p. 41) says with special reference to the Pine-beetle may be applied generally to other species of bark-beetles, many of which increase dangerously in numbers when once timber has been largely attacked by any moth or beetle, or when large numbers of trees are found anywhere in an unhealthy state of growth. His remarks are as follows :—

"**Preventive Measures.**—If moderate care be bestowed upon the management of woods the increase of Pine-beetles may easily be checked and their numbers very materially reduced. In the absence of large 'blow-downs,' the insects increase chiefly owing to the careless way in which timber is often managed. It is not at all unusual to find that the trees felled during winter are left in the wood or its neighbourhood till far into summer. Each Scots Pine that is so left attracts hundreds of Pine-beetles, besides other noxious insects, and in the month of June and July sends forth thousands upon their work of destruction. Even in woods that are regarded as being well managed this state of things may be seen, and the whole might be almost as easily prevented as permitted. When a timber sale is held in spring, the buyer is often allowed his own time to lift the wood, provided he has paid for it, whereas he ought to be bound to have it removed not later than the 15th of June, or otherwise to cause it to be peeled before that date. The same applies to timber designed for estate work. It is, of course, not enough simply to cart the wood to the sawmill and there allow it to lie. Such a course would do nothing to reduce the number of Pine-beetles. It must either be peeled or cut up, and in the latter case the slabs should be burned or peeled. If it can be managed, it is well to delay stripping the bark till near the middle of June, for there is but little danger of the young beetles escaping before that time, and by so doing time will be allowed for a larger number of beetles to utilise the trees for breeding purposes, and thus they and their larvæ can be destroyed in much greater numbers.

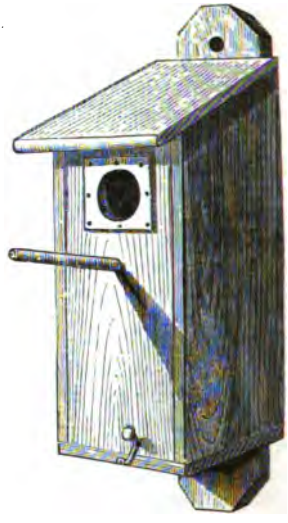
"Trees should be cut as close to the ground as possible, so that the minimum of stool-wood may be left on which the beetles can oviposit. The practice of trenching out the stools is very effective in keeping the insects in check; but on account of the attendant expenses it cannot be recommended unless a market can be found for the wood so obtained. On a steep slope, or on rough ground, it is quite impossible to cut so low as to avoid leaving high stools, and in such cases the bark should be as carefully removed as is practicable. In all cases where peeling is done, the bark should be burned. If it contained only eggs or larvæ, this would not be necessary, for these are situated close to the wood, and consequently perish when exposed to the influence of sun and air; but as pupæ may be present, and as these, in the case of thick-barked trees, are buried deep in the bark, they are still capable of developing into perfect insects even after the bark has been separated from the tree.

"The woods should be carefully supervised in all their stages, and trees which are diseased, enfeebled, overcrowded, or just dead, should be at once felled and removed, or peeled. It cannot be too strongly insisted upon that Pine-beetles are in no way kept in check by cutting down trees which have been dead for many months, and clearing them out of the wood. It is not in such trees that the beetles find the means of increasing, though they have already served this purpose. The object of the forester should be to anticipate the death of a tree, and have it removed before it is actually in a fit state to be appropriated by the insects.

"Birds and mammals that prey upon insects should be preserved and encouraged to increase. Gold-crested wrens, tree-creepers, and titmice

s indeed they are of all small insects.
e increase of titmice by erecting suit-
ng taken that the hole into the box
hat the boxes are fastened to dense-
height not exceeding 10 ft. from the
to a separate tree."

ation of useful birds has been above
ortant to do whatever lies within easy
pectivorous kinds. Despite its other
one of the most useful species, whilst
be encouraged and protected by the
3–336), so as to protect its eggs and
cuckoos, wild cats, &c. Many species
ited amount of damage to game, and



peckers, and other birds of about the same size.

of which they are killed off at every
armer, and the forester. Nevertheless,
ject were disseminated, these would be
ulturist and the sylviculturist; for they
ious insects than compensates for the
when the *natural balance* is disturbed
birds or animals, then noxious insects
ilst cuckoo, starling, creepers, titlarks,
are all unquestionably useful, finches,
s, kestrels, buzzards certainly do more
arrows, jays, magpies, and ravens may
rs on the whole. Among other ani-
polecats, stoats, and weasels may all
han harm from the forester's point

[illegible] sly been fully indicated, [illegible] rned for the trapping of [illegible] egard to attacks of cater- [illegible] e, no such remedies can [illegible] ons of sulphur, tobacco- [illegible] London purple, &c., be [illegible] nough for practical use [illegible] n remarked, when once [illegible]

Fig. 335.

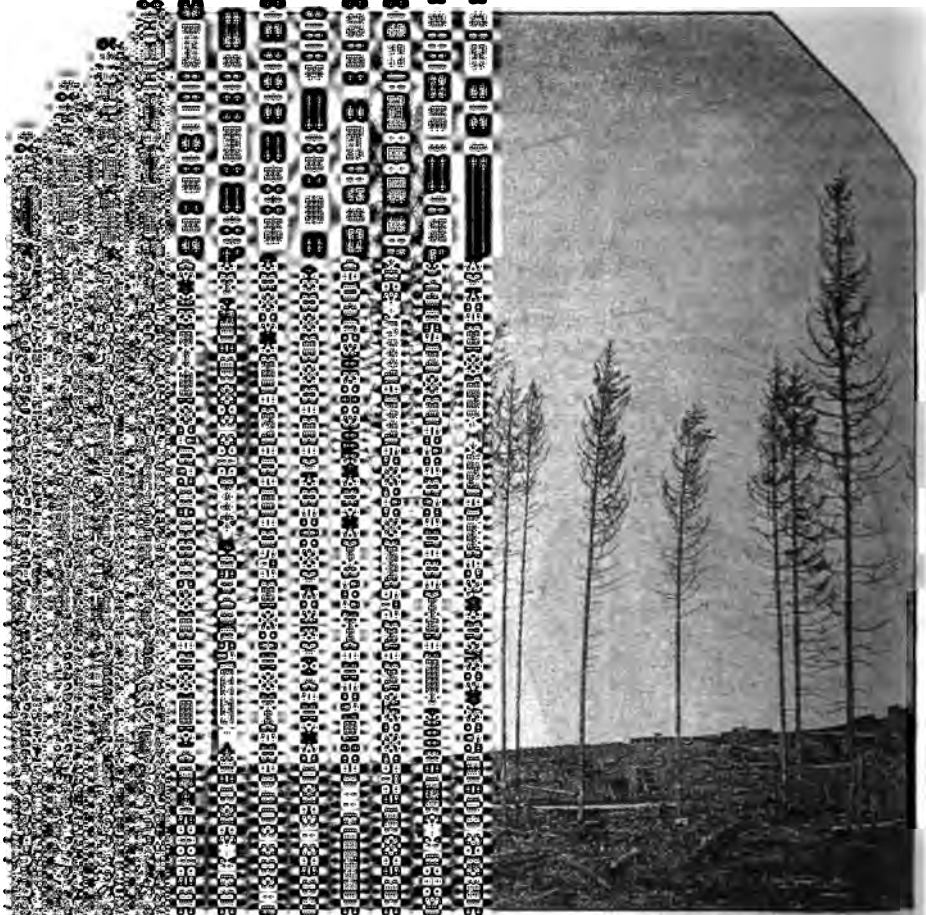
[illegible] or view of a Nesting-Box [illegible] the accommodation of a [illegible] ber of Tits, and similar [illegible] ll birds.

[illegible] attacks of caterpillars [illegible] of nature adjusts itself [illegible] abnormal increase in the [illegible] c. In addition to these [illegible] amount of damage also [illegible] ear following them.

[illegible] leaflet concerning *Insects on*

to stop the attack whenever it is
ried on the Continent consists of
described by the editor with regard
ri. Society Scot., 1893, pp. 199–205),

hen once they occur *en masse*, no
the moths, owing not only to their

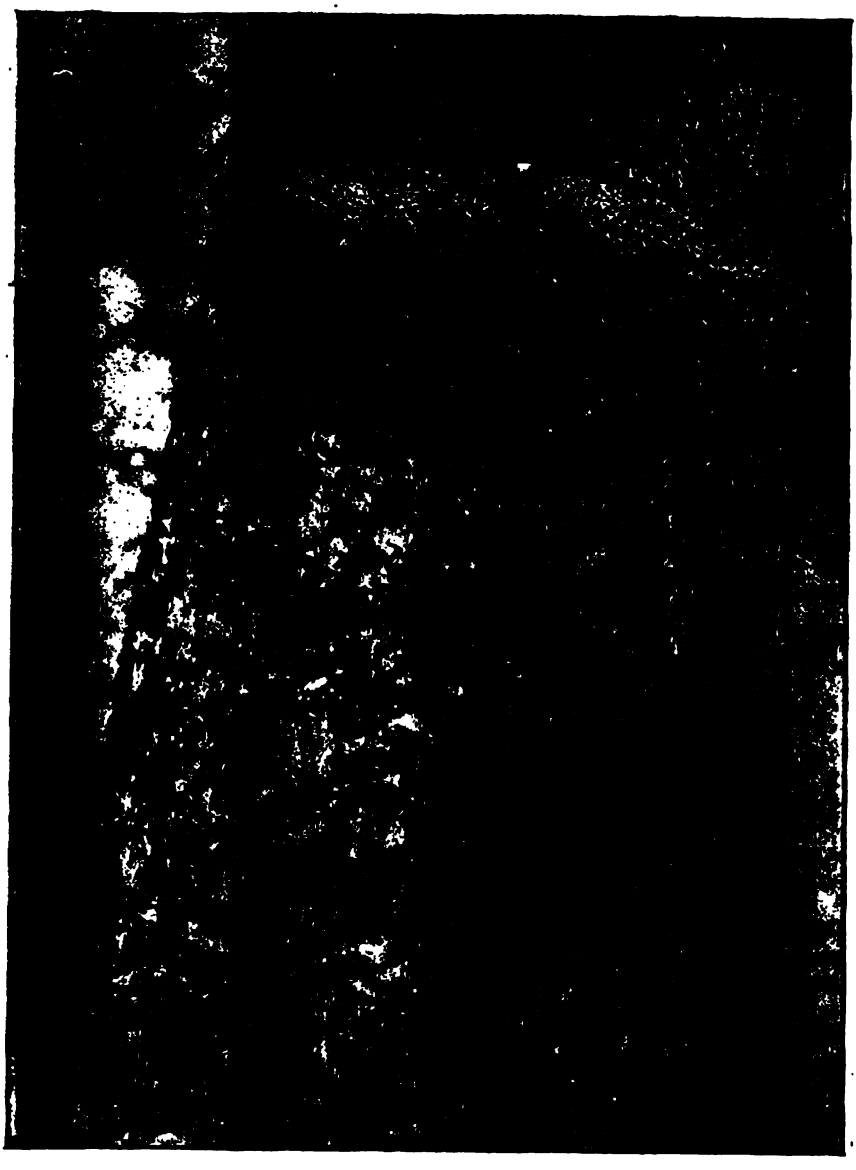


arance of the Spruce-trees that had been killed
e and there, which were mostly blown down by

the fact that they cover the trees up
owever, can be adopted, the destruc-
ure cutting off of about 90 in the
year. It was hoped that by means
ed localities in front of exhausters,

the moths might perhaps be decimated. But though long continued, the experiments were disappointing; the moths fluttered about in dense swarms

Fig. 338.

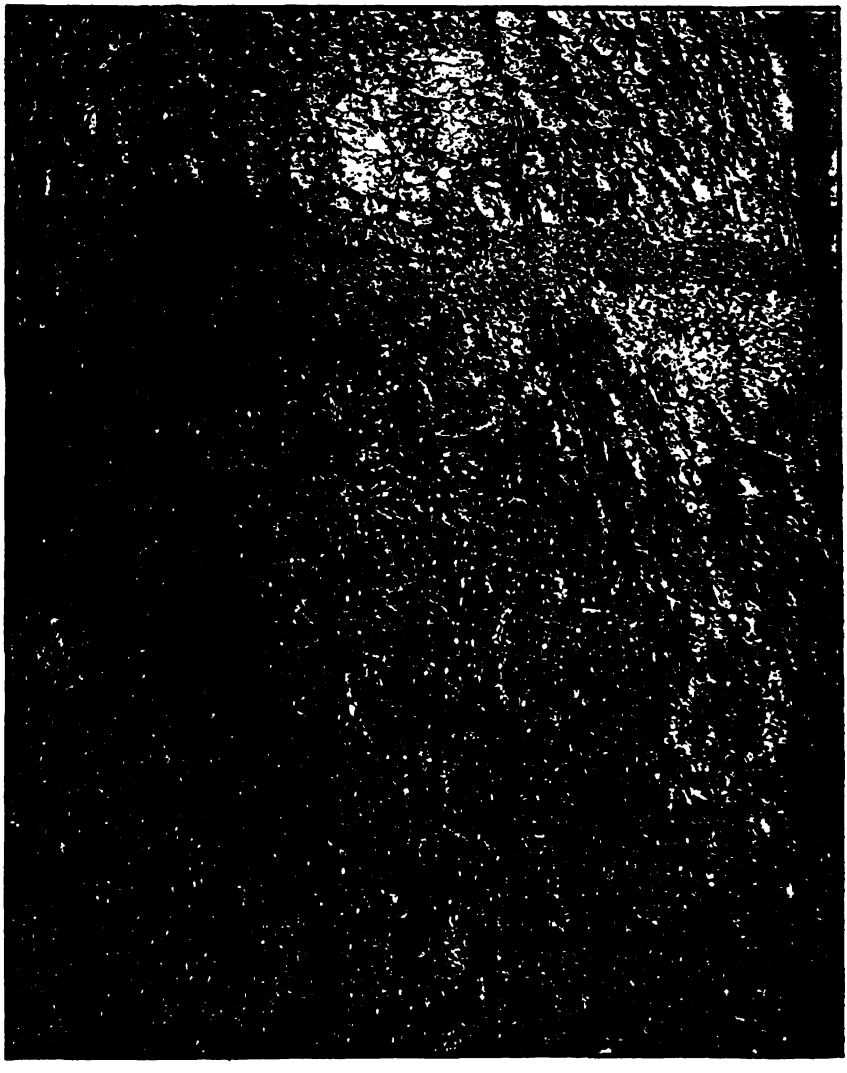


Young Caterpillars hindered by the girdle of patent tar from ascending the stem in order to commence feeding on the crown of foliage.

within the rays of the light, yet displayed no desire to approach close enough to be brought under the influence of the draught playing into the exhauster.

"*The main remedy* lies in placing around the stem (either about 15–18 ft. above the ground or else at breast-height) a girdle, composed of a viscous, gluey, or tarry substance, retaining its stickiness and odour until after the caterpillars have done feeding. The great practical utility of this

Fig. 339.

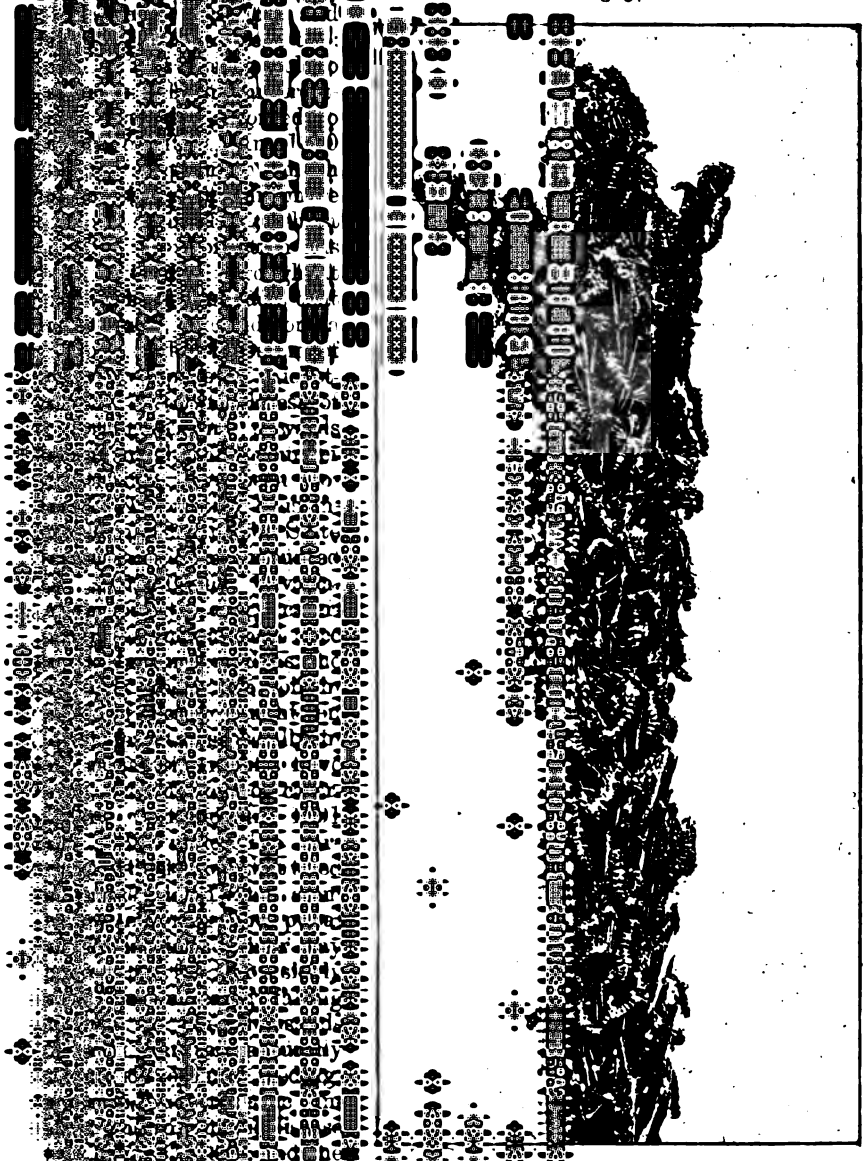


Caterpillars, after having spun themselves down from the crown, are unable to reascend the stem owing to the tarry rings.

method rests on the characteristic of the young caterpillars spinning themselves down to the ground on gossamer threads during the period before the second change of skin, after which their fully-developed destructive

[illegible] tems being prevented by [illegible] e, the caterpillars die of [illegible] 1889 in a small 15 to

Fig. 340.



[illegible] (1891) *swarming on the top shoots* [illegible] *Spruce-trees.*

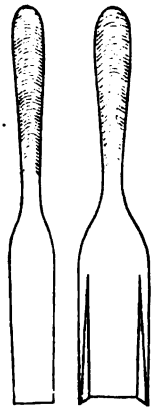
[illegible] pensive, and in practice it [illegible] thin patent tar being then

used, and the ring being formed by means of a long-handled brush fed from a reservoir above it. The extra expense of high rings is only recommendable when it is certain that a high percentage of the ova are situated on the lower portion of the stem.

"Whether rings of patent tar or glue at breast-height will or will not be sufficient to save the crop, depends principally on the species of tree, for, with its sparse foliage and less density of crown, Scots Pine is much easier to deal with than Spruce. Timely adoption of this measure can certainly minimise the evil; but when once the caterpillars swarm in enormous numbers, it can only be effective if aided by natural enemies of the insect, and by fungoid disease breaking out among the caterpillars owing to the sickly state engendered by hindrance of their usual daily progress up and down the stem towards the end of June or the beginning of July. Thousands of wooden nesting-boxes have now been hung throughout the coniferous forests in Bavaria to protect the increase of starlings (Figs. 333–336).

"At Ebersberg (1892) the average cost of forming the rings of patent tar has amounted to about 8s. per acre; the cost of the patent tar was 7s. per cwt. at the factory, and 13s. in the forest; whilst the labour of ringing the stems was 7s. per cwt. About 40 lbs. were used per acre on the whole average, so that the mean outlay per acre was 5s. 3d. for patent tar and 2s. 9d. for labour.

Fig. 341.



Spud and Smoothing stick (about 1-6th real size).

"Before the operation of applying the patent tar is proceeded with, a thinning out should take place in winter, when all suppressed stems and undergrowth should be cleared away. After that the boles must be cleaned wherever the ring is to be put, so that the semi-viscous patent tar may get a firm hold on the bark. For rough-barked trees like Oak and Pine, this cleaning should be about a span broad, but for smoother-barked species like Spruce, Silver Fir, and Beech, it is sufficient merely to free the part from moss and any scaly bark attaching.

"The composition of the patent tar or glue is treated as a sort of secret, but it must be an open one, as some fifteen or sixteen firms supply it at about the same price, 7s. to 7s. 6d. per cwt. at the factory. It consists mainly of wood-tar, resin, wood-vinegar, various oily ingredients, and probably black soap, and must possess the property of not congealing with late frosts, of remaining semi-viscous for over three months, and of not running with heat. It should float on water; if it does not, this proves that mineral ashes have been mixed with it, thereby diminishing its efficacy.

"The ring should be put on thick, but need not be broad, as the caterpillars dislike either the smell or the touch of it so much as to make no attempt to cross over; hence a breadth of $\frac{1}{2}$ to 1 in. and a thickness of $\frac{1}{6}$ to $\frac{1}{5}$ in. is amply sufficient. Owing to its semi-viscosity, the patent tar cannot be put on with brushes, but is affixed by means of special appliances, for it must bite close on to the bark so as not to peel or flake off in places.

"Apparatus of various sorts have been invented for putting it on, all of them being more or less like syringes in principle, but the simplest and best method, especially when the ring is formed at breast-height, is to apply the tar with a small narrow wooden spade about $\frac{1}{2}$ to $\frac{3}{4}$ in. broad, and to smooth it off with another slightly broader wooden instrument to the required breadth and thickness (see Fig. 341). The formation of the rings must be

undertaken early enough in April to be entirely completed by the time the larvæ issue from the ova.

"Observations on living trees and examination of dead stems have shown that no harm is done to the trees by the using of patent tar, and that it does not penetrate into the cambium to interfere with the normal performance of the functions of the latter, although it partially penetrates and softens the bark immediately below the ring."

Injuries Caused by Game.—It is a noteworthy feature in the rural economy of Great Britain that, speaking generally, more attention has been given to game-preserving than to economical forestry. This is true even of parts of the country which might be said to be specially well suited for planting. That such a thing should have happened is not at all surprising. From certain points of view it is no doubt regrettable, yet it is but the natural result of the growing demand for sport which has followed the increase of wealth amongst the middle classes in this country. Exorbitant rents have been readily paid for shootings of all kinds, good, bad, and indifferent, so that landowners have been tempted to give a good deal of attention to the rearing of game, with the result that in many cases forestry has had, as it were, to play second fiddle. No one can fairly blame landowners for taking advantage of the great demand for sport; by doing so they have in many instances derived a much higher rental from their property than could possibly have been obtained by any other means. Yet it is undeniable that game-preserving as pursued on a large number of estates is strongly antagonistic to profitable forestry. From hares and rabbits alone the loss must be very considerable, as on the greater number of extensive landed properties large sums are annually expended in the replanting of enclosures which have had their crops less or more injured, and sometimes almost totally destroyed. Startling facts could be given on this point; but reference will not be made to the cases of any particular estates, as that would necessarily imply remarks of a more or less personal nature with regard to the landowners. In many cases landed proprietors look upon their enclosed plantations as just so many game-covers; and in reality they are preserves, as on most estates the game can lie quiet for breeding purposes. On many estates, not even the forester himself is allowed to carry out the needful operations of thinning for fear of disturbing the game; yet if only the matter were properly understood, it would be found that there is no necessity for any such extreme disregard for the interests of the plantations.

In this work it is the sylvicultural aspect of the question that is the chief concern. In this view extreme game-preserving is much to be condemned. The forester is perhaps ordered to plant an enclosure

of about fifty acres. He thinks, as he proceeds with the work, that although there is a considerable quantity of game in the older enclosures, he has seldom seen much on the part he is about to plant. He encloses it, therefore, and no sooner is this done, than from its quietness it becomes the resort of hares and rabbits, although this may not have been the case previously while the land was pastured and in the hands of a farmer. It is enclosed, however, and he must plant it. The planting takes place; and not many months afterwards he finds the stems of the young Oak or Maples stripped of their bark and the tops of the Larch, or Spruce, or Pine all eaten off. And this goes on day after day, more especially in the winter-time, while the forester looks on helplessly; for although he may complain, his lamentations are not much attended to, because the gamekeeper protests that there are few hares, if any, in the enclosure, well knowing that he is expected to have a good stock for the coming shooting season. If ground game were kept more in check than at present in many cases, planting operations would not cost nearly so much as they now generally do, and their results would be vastly more satisfactory.

This matter was distinctly pointed to by Sir Herbert Maxwell, Bart., in his paper on *Woodlands*, where he says (*Nineteenth Century*, July 1891, p. 33) that—

"One chief hindrance to our woodlands being remunerative may be stated at once—we are arboriculturists and sportsmen, not foresters. A large proportion of the land returned as woodland is really pleasure-ground and game-cover. Thousands of landowners follow on a smaller scale the example set by the State on a larger in the New Forest and Windsor Forest."

This was a matter also distinctly brought before the notice of the Parliamentary *Committee on Forestry* in 1887, both with regard to England and to Scotland.

Thus, in the evidence of Mr Elliot, Professor of Estate Management at Cirencester College, the following passages occur with special reference to the conditions obtaining throughout Central and Southern England:—

"505. In other words, are we not as a nation very deficient in technical education as regards forestry?—Yes, I should say so, in comparison with other nations. There is one great drawback in connection with Forestry in this country, and that is the association of woods and covers with game-preserves; all agents will tell you that is a detriment to the full development of woods.

"506. Do you mean that the large covers which are now kept for foxes and pheasants might be kept for profitable Forestry?—If there were no question of game-preserving, more might be made of the woods.

"524. You stated, I think, that our woodlands are rather sacrificed to game in this country?—I rather said that the production in a commercial point of view is probably lessened sometimes by considering the advantages of sport rather than the growth of timber and underwood.

"525. Suppose rabbits are kept down, does it do any harm otherwise? —No. I suppose not; it is the rabbits that do the greatest amount of harm."

Similar evidence was tendered with respect to the Scottish woodlands. Thus the late Mr Macgregor, at that time head forester to the Duke of Athole, spoke to the following effect:—

"980. Is the growth of timber much hampered by game in Perthshire? —A good deal.

"981. By what kind of game chiefly?—I would begin at capercailzie, they destroy the tops of the Scotch firs; and hares and rabbits are the principal animals. I find that grouse are very apt to destroy young buds.

"982. You think the growth of timber is seriously hampered by game, in Perthshire?—If it is planted in large areas, not very much; but small belts are very much damaged by game."

And the evidence of the late Mr M'Corquodale, head forester to the Earl of Mansfield, on the point was as follows:—

"1371. Is it your experience that plantations in Perthshire have suffered much from game?—They have suffered very much.

"1372. There has been great loss by game?—Great loss. The rabbits and hares will eat the bark of trees from 80 to 100 years of age, Elm, Ash, and Beech. I have seen them peeling them, forcing themselves up as high as they can, and not leaving any of the bark two feet above the surface on.

"1373. You find game is very prejudicial to Forestry in Perthshire?—Yes, very."

Now **Sport** and **Forestry** are by no means incompatible; they are closely related, and may easily go hand-in-hand together. There is far finer shooting, far better *sport*, in the true term of the word, in the large forests of Germany than is anywhere to be had in Britain. The wild boar and the deer and roebuck shooting obtainable in the Harz Mountains, the Thüringian Forest, the Solling, and throughout the Pine-woods on the sandy North German plain is a far more sportsmanlike amusement than the best shooting obtainable in any part of Britain.

It is only when the woods consist mostly of small clumps scattered here and there throughout agricultural districts that hares and rabbits become **vermin**. But when there are extensive areas for game to roam about and feed, the evils that are so marked in small woods and plantations become greatly diminished; whilst the character of the sport offered is at the same time most distinctly raised. Existing **deer forests** in the Highlands of Scotland might therefore quite easily be planted up without the danger of ruining the sport; for the stalking of the red-deer, and of that charming object of sport the roebuck, would offer additional zest to the true sportsman.

Prevention of Injuries by Game.—In practical Forestry it is found that the whole number of the trees that may have been originally planted upon the ground cannot be accounted for in the course of thinning and training up. The results of notes kept over a long series of years regarding the management and thinning of a vast extent of woodlands of all ages, show that, even under very good management, 8 per cent. will be found missing when the season of

thinning commences. The reason of such deficiencies occurring is that, while the plants are in a very young state—say during the time that they are under five years of age in the plantation—they are liable to be attacked by animals of every description, such as hares, rabbits, mice, squirrels, moorfowl, &c., &c. Hares and rabbits destroy young trees, both nurses and hardwoods, by gnawing the bark upon the stems and branches. Young trees of three-quarters of an inch in diameter, may often be seen completely cut through by hares and rabbits. Trees are thereby entirely destroyed if of the Pine and Fir tribes; but of course hardwood trees, although gnawed over, will again come away by shooting from the stool. Mice and squirrels injure young trees by eating out the buds. If the winter and spring happen to be a severe one, they also peel the bark from young trees wherever they can reach it; and when severe frosts set in, trees so injured very frequently die in consequence of the frost affecting them at the peeled part. Moorfowls are very destructive to young Scots Pine plants, by picking out all the buds of the leading-shoots; and from this cause alone very many young trees may often be rendered useless.

On most estates where game is preserved to any considerable extent there is often experienced, more especially in the neighbourhood of the home grounds, a very great difficulty in getting a crop of young trees to grow satisfactorily, in consequence of hares and rabbits gnawing their bark and young branches; and in parks kept for deer, during severe winters both stags and hinds, if not well supplied with food, will strip the bark from old trees, much to the injury of many fine and otherwise healthy specimens.[1]

Ground-Game.—Hares and rabbits may be prevented from peeling the bark and young shoots of young trees by the frequent application of a mixture of cow-dung and soot in equal proportions. This should be made thin enough with water to admit of its being applied to the trees with a brush, in the form of a regular coating over the bark; and the application of this coating should be made so far as the animals can reach. The operation involves a certain amount of outlay; hence, where there is a large extent of plantation to be operated on, it would often be preferable to reduce the quantity of game. Where only a few trees are to be protected, however, the case is different; and the process may with propriety be persevered in till they are so strong as to be practically out of danger.

[1] This soon develops into a *habit*. The practice that is begun during winter, for the sake of obtaining food or certain tonic ingredients contained in the bark (when the deer are fed extensively on hay), is often continued through sheer wantonness into the spring and summer, when the bark strips more readily. See Kauschinger-Fürst, *op. cit.*, p. 96.

The mixture described is, when applied to the bark of trees, as effectual in preventing deer from injuring them as it is in the case of hares and rabbits; but the pigment requires to be applied frequently in order to keep it effectual.

Various other mixtures have been used for the purpose under notice, and with different degrees of success. But, with the exception of the preventive measure described, they have all more or less an injurious effect on the healthy action of the bark of the trees to which they are applied; they cannot therefore be recommended by the author. The mixture of cow-dung and soot he found to have no bad effect whatever on the health of the trees to which it may be applied; and as, when frequently applied to the bark, it prevents deer, hares, and rabbits from interfering with them, he recommends it as a safe and certain preventive.

The following simple and very inexpensive method, adopted for the protection of young coniferous plants up to about 10 or 12 years of age, is described by Kauschinger-Fürst (*op. cit.*, p. 95):—

"Subordinate species that are interspersed only individually—Larches, Weymouth Pine, and exotics planted experimentally—can be protected against the brushing of roebuck by binding brushwood round them, by fixing rugged branches near them in the ground, by tying on with a thread little pieces of newspaper, about 4 in. square, that have been cut up at home, at a height of 20–24 in. above the ground, or by smearing the stem with any mixture having an objectionable smell, as, for example, lime mixed with bullock's blood and urine.

"This method was first introduced at Grubenhagen (Hanover), more than twenty years ago, by Oberförster Niederstadt, under whom the translator had the benefit of serving his apprenticeship in Forestry during 1873–74. The small square bits of paper were tied with rushes round the topmost buds of Silver Fir in autumn, and generally remained till the following autumn, like a collar at the base of the new shoot."

Wire-netting can always be applied to prevent hares and rabbits getting into a plantation; but of course in this case the plantation requires to be completely surrounded with it in order to keep the animals out. In many instances small plantations may be entirely enclosed with the netting, which succeeds perfectly in preventing them getting in to injure the trees. On a large scale, however, this would become too expensive; and it is the less likely to be successful, as it would not be so easily looked after as in the case of a small enclosure.

The netting should be inserted about 4 in. into the ground, and then bent slightly outwards, in order to prevent rabbits from burrowing under it. In the Highlands of Scotland most damage is done to small hillside plantations by the blue hare (*Lepus variabilis*) in winter. Sometimes these animals form well-trodden runs round the fencing in their perambulations in order to see if they can effect an entrance (see chap. viii. vol. ii. p. 74).

Wire-netting may also be applied to protect large trees from deer in a park, by fixing it round the trees high enough to prevent the animals reaching the bark above it.

Every landed proprietor who wishes to be really successful in the rearing of his plantations, should destroy the animals above referred to; by doing this, much labour and considerable expense would be avoided in replanting. The author is glad to be able to state here, however, that many proprietors are now destroying the hares and rabbits on their estates, in order to prevent injury being done to their plantations by these animals. Were all landed proprietors to look to their interests in this way, no great amount of injury would ever be complained of in respect to their young plantations.

CHAPTER XIII.

THE RATE OF INCREMENT IN CROPS OF GROWING TIMBER, AND THE BEST MEANS OF MEASURING OR ESTIMATING IT.

Rate of Growth of the Different Kinds of Trees.—There is no part of a forester's education in Britain more neglected than that of giving him a thorough knowledge of the size and cubic contents of different kinds of woodland crops, on given qualities of land, and at different ages. Such a knowledge can only be obtained by a careful collection and tabulation of the data yielded by as many concrete cases as can possibly be made available. For many years the author, in surveying and valuing plantations throughout England, Ireland, and Scotland, endeavoured to collect and tabulate definite and precise information upon this point, which is included within the present chapter. The results of his experience, after having examined plantations of many kinds, upon a great variety of soils and situations, as well as under many descriptions of management, have led him to the conclusion that the size of a tree at any given age upon any given situation does not depend so much upon natural circumstances as upon the artificial management it may have received. In illustration of this, he may mention that he has surveyed plantations in England which were growing upon a very favourable soil and situation, and which, compared with others of a like age in Scotland, on a soil rather unfavourable, were, notwithstanding, far inferior to the latter, —this being occasioned by bad management in the one case, and good treatment in the other. From such cases it may be seen that the grower of wood, like the cultivator of any other product of the soil, has much in his power towards making the crop profitable or not, even where natural circumstances may seem unfavourable.

Granted, however, that the system of management is what may be termed good rational treatment, then the quantitative, qualitative, and monetary yield of the timber harvested will, of course, vary directly with the productive capacity or fertility of the land, and with the general suitability of the soil and the situation with regard to the specific requirements of the genera and species of trees cultivated as woodland crops.

Well-educated foresters on the Continent of Europe, and especially those in Germany and France, have for a long time past made this branch of forestry a special study in their forest economy; and from this it follows that at the present time they are very much superior to British foresters in respect to arriving at the prospective value of any woodland crop. This point is specially referred to here, in order, if possible, to stir up all foresters to the systematic collection of data concerning crops of trees, in respect to the size each species ought to be on a given soil and situation, at any given age. Without such knowledge no man is capable of undertaking the management of extensive woods with anything like credit to himself or the greatest possible profit to his employer.

Mere arboricultural details, for individual trees only, are of no use practically. The only safe guides are statistics regarding crops grown in the close canopy of woodlands. Whenever details of the latter description are available, they should be registered, and collated with similar data obtained elsewhere in Britain; for, the larger the number of actual measurements, the truer will be the *average results*, which are chiefly required for general guidance.

It would be impossible for the author to give here the size which trees ought to attain on every variety of soil and situation, and under all circumstances of management, as so much depends upon both artificial and natural local circumstances. For example, he has frequently seen a plantation of trees, which had been growing at a rapid rate, and making great progress in growth in diameter, suddenly checked in health by an over-thinning, and afterwards, in consequence, making but little progress; while, on the other hand, he has as frequently seen the trees in a plantation, which had been for a time in a confined state, and had consequently been weak in increment, rapidly enlarge the diameter of their stems after being judiciously thinned. Again, with regard to natural local circumstances, he has often observed trees growing on a situation much sheltered by older woods, &c., making great progress in growth in girth; while in another plantation not far distant,—formed upon the same description of soil and altitude, and under the same system of management as the other, but much more exposed to the free influence of the natural climate,—trees of the same sort were making much less advance. In giving the results of his measurements as to the periodical increment on trees, he therefore begs it to be understood that these are given merely as an average of what ought to be the result at certain ages, and under fair circumstances with regard to situation and to management.

It is now a well-ascertained fact that the growth of trees, both with respect to their increase in height and to the depth of new wood

laid on their stems, is not alike in every year. The author had many opportunities of observing this in all the common kinds of trees while thinning plantations, and took notes which led him to the conclusion that the differences found in the growth of trees in different years represent a record of the influences of the seasons upon the growth of trees.

Taking a transverse section of a tree of some considerable age, it will perhaps be found that in one particular year the layer of new wood will measure nearly $\frac{3}{8}$th of an inch in depth, and that the next layer above it will not measure over $\frac{1}{4}$th of an inch, while the one outside of this may not be much over $\frac{1}{8}$th of an inch, and so on, very few of the consecutive annual layers being found alike in any tree.

Similar differences occur in the annual growths of the branches lengthwise, and in those of the tops upwards. In cutting down trees as thinnings from plantations in perfect health, he often remarked that the top growths of most of the trees felled were, at the time he operated on them, from 18 to 22 in. in length, while those of the previous year measured only from 12 to 18 in.; and in examining the stems throughout the whole of their length, he found that proportionate differences in the growth of the stems lengthwise had taken place in previous years as well. Such differences as these will be found in the growth of trees in all plantations. They can be accounted for only on the principle that seasons which are very favourable for the growth of wood give rise to a great degree of vitality in trees, and consequently to their laying on a large amount of woody matter; while seasons of an opposite character have a tendency to lessen the vitality of trees, and therefore the amount of woody matter they lay on is lessened accordingly.

All kinds of trees are not affected alike in the same season, however, as it will be found that, generally speaking, the deciduous sorts make their greatest growths in dry seasons, while the Spruces and Silver Firs make their greatest growths in seasons that are generally of a wet character; and, on the other hand, the Larch and Pines invariably make their greatest growths in seasons of a moderate character. The author would also add that, in very dry seasons, the Spruces and Silver Firs make comparatively small growth, and are sometimes even killed if they are not on a soil of a cool-bottomed nature.

The above remarks of the author bear more especially on a portion of the subject of Forestry which has already been treated of by the editor in another part of this work (see vol. i. p. 332).

In making calculations as to the periodical increment of timber, the author has invariably measured the trees at about 8 ft. from the

ground; and, for the sake of better illustration, he has reduced his calculations to the following three distinct classes of situation:—

I. The average periodical increment in trees growing on a favourable soil and situation.

II. The average periodical increment in trees growing on moderately favourable soil and situation.

III. The average of the growth of trees growing on comparatively unfavourable soil and situation.

On the Continent the various soils and situations are assessed, with reference to their general fertility or productive capacity, either on the decimal system, or are ranged as belonging to one or other of five classes. The decimal system (in which soil of the best quality is = 1.0) is not found to be practically advantageous, as it is more difficult to attempt to estimate correctly as 0.5 or 0.4, than to decide in a general manner if it be, on the whole, deserving of being classed as "*average*" or merely "*indifferent*" for any given kind of tree-crop.

The practical utility of some method of classification is obvious. But it seems to the editor that the author's limit of three classes—which would practically mean I. good, II. average, III. inferior—is somewhat too inelastic; whilst the decimal system is too complicated. The best system to adopt is that of having *five qualities of soil and situation*, as follows:—

I. Very good. II. Good. III. Average or moderate. IV. Inferior. V. Poor.	This classification can only, however, be held to apply to the particular kinds of crop that are being specially considered.

As the editor has elsewhere remarked (*Studies in Forestry*, 1894, p. 114):—

"Such assessments are very useful, but are in each case only relative; for a soil that might only be regarded as inferior so far as the cultivation of mixed crops of Oak, Maple, Sycamore, Larch, Douglas Fir, and Beech are concerned, may perhaps be classifiable as a moderately good, or even a good soil, if regarded from the point of view of woods in which Scots Pine and Spruce were intended to be the ruling species."

In order to obviate uncertainty regarding classifications as to the general quality of *soils and situations* in different parts of Germany, the Committee in charge of the various experimental stations, at which investigations connected with Forestry are being made, in 1888 determined upon the adoption of the following scale for assessing the quality of forest-land (Weber, *Lehrbuch der Forsteinrichtung*, 1891, p. 135). It must, however, be expressly noted that the assessment is for the given species of crop only: thus Pine soil I. quality is not equal in productive capacity to Spruce and Silver Fir I. quality, or necessarily even equal to Beech soil II. quality.

Quality of soil and situation.	Cubic feet per acre (without root-wood) yielded by crops of 100 years in age.		
	Scots Pine.	Spruce and Silver Fir.	Beech.
I.	10,150	15,950	10,440
II.	7,975	13,050	8,410
III.	6,090	10,440	6,670
IV.	4,350	7,975	5,075
V.	2,900	5,800	3,625

These data may, however, be compared with those given in *British Forest Trees*, 1893, p. 44. They are for German woodlands; but there is no climatic reason why precisely as good, or perhaps even better, results should not be maintained if our woods were originally formed of the most favourable density, and managed on sound sylvicultural principles with regard to the maintenance of a normal density of leaf-canopy.

I. Rate of Growth in Height.—The rate of growth in height, girth, and cubic contents has been elsewhere dealt with by the editor, viz., in *British Forest Trees*, 1893, pp. 35–46, and in *Studies in Forestry*, 1894, chaps. ii. and iii. In the present work, however, he takes the opportunity of bringing before the British public concerned with, or interested in, Sylviculture the statistical data compiled by other authorities than those previously quoted in either of the above books. The works he has selected for citation in the present instance are Burckhardt's excellent *Hülfstafeln für Forsttaxatoren*, 1861, and Weber's *Lehrbuch der Forsteinrichtung*, 1891. The latter gives data referring more generally to the whole of Germany; whilst the former were compiled almost solely from data obtained throughout the kingdom of Hanover, which extended from the Harz Mountains to the sea-board at the mouth of the Elbe. The Hanoverian results might therefore be taken as fairly applicable to Britain, provided our woodlands were only as well managed as the Hanoverian forests. Burckhardt's tables have appeared in later editions, but the first issue was the only one that was given in cubic feet; hence it is here consulted for convenience.

During the years 1872 to 1882 the author devoted considerable attention towards ascertaining, by continuous measurements, what height a tree of a given species should attain at a given age. The results of his measurements are contained within the present section. He made measurements of the lengths of trees of the various kinds usually grown in our plantations, as these were cut down as thinnings, at the ages of 10, 15, 20, 25, 30, 35, and 40 years; and the results of these measurements are given in the following statements. It must be understood, however, that the heights stated in respect to each species are the results of many averages, as in no other way can a fair statement of height be given with regard to trees growing in plantations. For example, Larch at 10 years of age may in some plantations be found measuring 28½ ft. in height; in others, it may be about 20 ft.; while in others again, it may only have attained about 12 ft. in height. Therefore only the average heights of many trees of the same species are given for the different ages stated in the following tables.

The editor would here take the opportunity of urging upon foresters the necessity for collecting all data of this kind—for height, girth, and cubic contents—and arranging them according to the quality of the soil, as I., II., III., IV., or V. In this form the average figures for each quality of land, so far as the specific kind of tree is concerned, give a far truer and more valuable guide than generalisations of a still broader nature. The larger the number of measurements from which the averages are struck, the greater will be the accuracy of the average figures; but the less likely will they be to apply accurately to any particular locality.

I.—Broad-Leaved Trees.

Age of trees.	Oak.		Beech.		Ash.		Scots Elm.		Lime.		Sycamore.		Sweet Chestnut.		Horse-Chestnut.		Black Italian Poplar.	
Years.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
10	14	0	11	6	20	0	16	8	15	8	18	6	18	9	19	0	29	10
15	20	6	17	10	28	10	25	0	22	0	26	6	25	0	27	0	43	0
20	27	0	24	0	35	10	33	0	28	0	34	0	32	0	33	0	56	10
25	33	0	29	10	43	0	40	6	34	0	40	0	38	0	37	9	68	0
30	39	0	35	8	50	0	47	0	40	0	44	10	42	0	41	6	75	11
35	44	7	41	0	55	9	52	6	44	6	49	0	46	6	44	0	81	6
40	77	6	46	6	61	0	56	0	49	0	53	10	49	8	47	0	86	8
	Inches.		Inches.		Inches.		Inches.		Inches.		Inches.		Inches.		Inches.		Inches.	
Average annual increase in height up to 40 years of age	14¼		14 nearly		18 nearly		16¾		14½		16		15 nearly		14		26	

II.—Coniferous Trees.

Age of trees.	Douglas Fir.		Larch.		Scots Pine.		Silver Fir.		Spruce.	
Years.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
10	24	10	18	6	17	0	12	6	20	0
15	36	8	26	8	24	8	23	10	28	6
20	49	6	34	8	33	0	34	10	37	6
25	60	9	43	10	41	6	44	0	46	6
30	71	0	49	0	47	6	53	8	54	8
35	...		54	9	54	0	62	0	61	0
40	...		58	7	59	7	68	10	66	0
	Inches.		Inches.		Inches.		Inches.		Inches.	
Average annual increase in height up to 40 years of age	28 nearly up to 30 years of age.		17½		17¾		20½		19¾	

The above data can only be viewed as merely local. For the author records concerning them that the—

Lime and Sycamore measurements refer to thinnings in Yorkshire.

Sweet Chestnut and Horse-Chestnut measurements refer to thinnings in Yorkshire.

Ash and Scots Elm measurements refer to thinnings in Fifeshire.

Oak and Beech measurements refer to thinnings in Shropshire.

Poplar and Douglas Fir measurements refer to thinnings in trees standing alone in various parts of Great Britain.

Larch and Scots Pine measurements refer to thinnings in various parts of the West of Scotland.

Silver Fir and Spruce measurements refer to thinnings in various parts of the West of Scotland.

The editor must draw attention to the fact that no details are given by the author regarding the nature of the **density of the leaf-canopy** of the woods in which the measurements were made. This is a point of essential importance, and a matter in which the closer woods of the Continent stimulate the individual trees to a greater rate of upward growth—by concentration of the vital energy into a struggle for light, and even for life—than can possibly be the case in the majority of our existing woods, which are treated rather in an arboricultural than in a scientific and sylvicultural manner. Thus, the data given for Poplar and Douglas Fir standing alone are of little use for sylvicultural purposes, except merely to indicate the general energy of growth of these genera of trees.

He must also call attention to the fact that the above data give no correct indication as to the true height of the more vigorous portion of the crop; for, of course, the mere thinnings cannot be regarded as exhibiting the normal height of the *taller* individuals still left forming the crop after the thinning has taken place.

The editor begs that the reader will not misunderstand these remarks. They are not made, *malo grato*, in any carping spirit, but with the express intention of directing foresters to the proper manner of collecting and tabulating important information that would, if well compiled, be of great practical utility for future operations of Sylviculture throughout Britain.

For the ordinary qualities of soil and situation to be found in the neighbourhood of Giessen in Hessen (near Frankfort on the Maine), Gustav Heyer (*Das Verhalten der Waldbäume gegen Licht und Schatten*, 1852) found (by analyses of the stems) the following to be the average rates of growth of the different kinds of crops, whilst forming woods growing **in normal density of leaf-canopy** for the given species of trees:—

Age of crop.	Larch.	Weymouth Pine.	Scots Pine.	Spruce.	Oak.	Beech.	Ash.	Maple.	Sycamore.	Elm.	Aspen.	Birch.	Alder.
Years.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
10	20.00	8.25	5.61	1.00	3.30	1.65	1.00	3.30	1.65	5.94	10.00	10.00	6.60
20	46.20	25.41	21.45	16.50	18.15	15.51	17.49	18.15	14.85	19.14	29.80	30.69	21.45
30	66.00	42.90	40.59	37.29	35.64	33.00	36.30	35.64	33.00	37.95	47.85	46.86	40.59
40	84.15	57.75	53.79	55.11	51.48	49.50	53.79	49.50	52.14	55.44	62.04	61.05	57.75
50	95.70	70.29	69.30	67.65	64.35	62.04	66.00	62.04	64.35	66.99	72.60	72.60	70.29
60	...	....	80.19	78.54	75.24	72.60	75.07	70.95	73.59	75.90	80.85	80.19	79.20
70	...	...	87.45	86.79	83.49	80.19	81.67	77.55	80.19	81.84	85.80	...	84.15

The editor would invite a comparison of these **sylvicultural data** with the more purely **arboricultural data** furnished by the author. But in the above tables there are certain results that decidedly call for remark. Thus, with regard to Ash, which is shown as being only 1 ft. high at 10 years of age, the analyses of the stems must have been made on individual trees that had germinated under the canopy of a high-forest of normal density; and, evidently, although the seedlings were able to *exist* during the first 10 years of their life, yet they were not placed in a position which could enable them to develop normally. In such a case it is only when the tree-forest overhead was cleared away that the young Ash plants could get any fair chance of thriving; and the soil must have been fairly good to have enabled them

to exist at all under such a degree of shade as prevented them making any larger rate of growth than merely 1 ft. during 10 years.

For the formation of mixed woods a careful study of such a table gives invaluable information with regard to the forecast of thinning operations. But this can only be of use as a general guide; for in all concrete cases the actual conditions of growth of the crops under consideration must be carefully studied by the forester on the spot.

The operations of nature are very frequently carried on in a manner which, according to human economic ideas, are wasteful; for throughout the whole of nature there is a tendency towards dissipation of energy, whereas all human efforts have the conservation of energy for their object. This may easily be exhibited in tree-growth. If any excess individual growing-space be allowed over the amount actually requisite for the healthy performance of the vital processes of transpiration and assimilation, then a coronal development and a lateral expansion must take place, to a greater or less extent, at the expense of the energy of growth upwards, *i.e.*, of the rate of growth in height. But, by endeavouring to maintain a normal density of canopy, the effort is made to concentrate most of the energy of vegetation for the express purpose of forming a long straight stem, free from branches and knots.

II.—Rate of Growth in Girth.

I.—Broad-Leaved Trees.

Kind of tree.	Diameter in inches at 8 ft. above the ground.									
	Oak.			Sycamore.	Ash.	Black Poplar.	Scots Elm.	Sweet Chestnut.	Beech.	Birch.
Quality of soil and situation. (I. = good. II. = average. III. = inferior.)	I.	II.	III.	II.	II.	I.	II.	II.	II.	II.
Age, years.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
10	1.25	0.75	0.25	2.25	1.50	6.00	1.50	2.50	2.00	0.50
15	...	...	...	...	...	10.00	4.00	4.50	4.00	...
20	4.50	3.00	2.00	5.50	4.50	15.00	6.00	7.00	6.50	2.50
25	...	...	...	...	...	21.00	8.50	8.50	9.00	...
30	9.50	7.00	4.00	9.50	7.00	26.00	10.00	10.00	10.50	7.00
35	...	...	...	11.50	9.00	29.50	12.50	11.50	15.00	...
40	16.00	12.50	8.00	13.00	10.50	33.00	14.50	13.50	17.00	10.00
45	...	...	...	15.00	12.00	36.50	16.00	14.50	19.50	...
50	20.50	16.00	9.00	16.50	14.50	39.50	17.50	15.00	21.00	12.00
55	...	...	...	18.00	17.00	42.00	19.00	16.50	22.50	...
60	25.50	18.00	10.00	19.50	19.50	43.00	21.00	17.50	24.00	14.00
65	...	...	...	21.00	22.00	...	22.50	19.00	25.50	...
70	29.00	19.50	11.00	22.50	24.00	...	23.50	20.00	27.33	14.50
75	...	...	...	23.50	26.00	...	24.50	21.00	28.25	...
80	31.50	20.50	11.50	25.50	28.00	...	25.50	22.00	29.00	15.00
85	...	...	...	27.50	30.00	...	26.00	22.50	30.50	...
90	32.75	21.50	...	29.00	31.50	...	27.00	...	...	15.00
95	...	...	...	30.00	33.00	...	...	...	...	...
100	33.50	22.00	...	31.50	34.00	...	28.00	...	...	...
105	...	...	...	33.00	34.50	...	...	...	...	...
110	...	...	...	34.00	...	...	...	...	...	...
120	34.75	...	...	...	...	...	...	...	...	...

II.—Coniferous Trees.

Kind of tree.	Diameter in inches at 8 ft. above the ground.									
	Larch.			Scots Pine.			Spruce.			Silver Fir.
Quality of soil and situation. (I. = good, II. = average, III. = inferior.)	I.	II.	III.	I.	II.	III.	I.	II.	III.	II.
Age, years.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
10	2.50	1.25	...	1.75	1.00	...	2.75	1.25	...	1.50
15	5.00	3.00	2.00	4.50	3.00	0.50	5.00	3.00	1.33	8.00
20	9.00	7.00	5.00	6.50	4.50	2.50	7.00	5.50	3.25	12.75
25	11.00	9.00	6.00	10.00	6.00	4.00	10.00	8.00	4.50	15.75
30	13.50	11.00	7.50	12.00	7.50	5.50	13.50	11.00	5.50	18.00
35	17.00	13.50	8.00	14.00	9.00	6.00	15.00	13.00	6.00	24.00
40	22.00	15.50	...	16.00	10.50	6.50	17.50	15.00	...	28.50
45	23.50	16.50	...	17.50	12.00	7.00	18.75	16.00	...	30.00
50	24.50	17.00	..	19.00	13.50	7.25	20.00	17.50	...	32.00
55	25.50	17.50	...	20.50	14.50	...	21.25	18.00	...	33.75
60	27.00	18.00	...	21.50	15.50	...	22.75	18.25	...	36.50
65	28.00	...	...	22.50	16.50	...	23.50	18.75	...	37.75
70	29.00	...	...	23.25	17.00	...	24.50	19.00	...	...
75	30.00	...	...	24.00	17.50	...	25.50	...	...	...
80	30.50	...	...	24.50	18.00	...	26.25	...	...	...
85	...	...	...	25.00	...	...	27.00	...	...	...
90	...	...	...	25.25	...	...	27.75	...	...	...
95	...	...	...	26.00	...	...	...	...	...	...
100	...	...	...	...	...	...	...	...	...	...
110	...	...	...	...	...	...	...	...	...	...
120	...	...	...	...	...	...	...	...	...	...

The statements relative to the Oak have all been taken in cutting down timber at the different ages specified; and the numbers given under each head are the averages taken from many trees of the same age. The most prominent feature of the statement is that, upon favourable soil and situation, the Oak not only grows more rapidly and attains a greater diameter of wood in a given number of years, but also continues to grow longer healthily, and to lay on a greater bulk of wood at a great age, than the other trees of the same species on less favourable soils and situations. Oak-woods that are grown upon a favourable soil and situation will still continue to make considerable progress at from 90 to 100 years of age; while another crop of the same sort of trees, if growing upon a less favourable soil and situation, will have culminated in rate of growth, and have almost ceased to add any perceptible amount of timber, by the time it arrives at that age. Between 90 and 120 years of age, the tree has, in the former case, increased in its diameter to the extent of 2 in.; while, in the latter, only half-an-inch is made during that period of 30 years. It will thus be seen that on an unfavourable soil and situation the wood will yield the largest annual average quantity of timber if it be cut and utilised

between 60 and 70 years of age, and on the moderately favourable soil between 80 and 90; while upon the favourable soil it may be left growing till perhaps 140 or 150 years. At first sight it may seem that 2 in. in diameter is but a small amount of wood to be laid on by a tree during a period of 30 years, as in the case of the Oak in the first class between 90 and 120 years. But, even if the stem of such a tree be only 20 ft. in length, it will have laid on during that period at least 14 ft. of extra timber, which, at 3s. per foot, gives £2 2s. of additional value in the wood produced.

It must, however, be distinctly pointed out that the sylvicultural and most truly economical manner is to secure the greatest possible height or length of clean bole first of all, by means of a normal density of canopy for the kind of crop in question, and then, when that is secured, to increase the growing-space of each individual tree gradually so as to stimulate the rate of growth in girth. This is the scientific Continental method of growing timber.

It must again be noted that the author's statistics appear to be only for thinnings, and are therefore, in all probability, only taken from trees which do not show such good dimensions as are to be expected in those that remain forming the main portion of the still growing crop. And this is a very important point.

What Loudon says (*Arboretum et Fruticetum Britannicum*, 1838, vol. iii. p. 1809) of the Oak may be applied to all our forest-trees grown as crops with a view to remunerative returns from the capital invested :—

"*The age at which Oak timber ought to be felled, with a view to profit*, must depend on the soil and climate in which the tree is grown, as well as on other circumstances. Whenever the tree has arrived at that period of its growth that the annual increase does not amount in value to the marketable interest of the money which, at the time, the tree would produce if cut down, then it would appear more profitable to cut it down than to let it stand."

And the following passage from the same work is interesting :—

"A writer in the *Gardener's Magazine* states that Mr Larkin, an eminent purveyor of timber for shipbuilding, stated, when examined before the East India Shipping Committee, that, in situations the most favourable for ship-timber (the Weald of Kent, for example), the most profitable time to cut Oak was at 90 years old; as, though the largest scantlings were produced at 130 years' growth, the increase in the 40 additional years did not pay 2 per cent. (*Gard. Mag.*, vol. xi. p. 690)."

Instead of giving the diameter at periods of 10 years, as for the Oak, in the case of conifers and most of the broad-leaved trees periods of 5 years were chosen. The reason for this is that the periodical thinnings are generally made at or within periods of 5 years; consequently it is an object of importance to have an estimate of the diameter which they should, in general cases, attain at periods of 5 years.

The details furnished with regard to the Ash and the Sycamore were taken from measurements of trees cut down on the estate of Arniston, as well as upon some other estates in Mid-Lothian, all of which were growing under what seemed moderately favourable cir-

cumstances as to soil and situation. No measurements were obtainable for land of the I. or III. quality, as these genera of trees are usually grown on land of medium quality only.

The results given for the Scots Elm were taken from an average of trees growing upon a moderately favourable soil and situation; whilst those for the Poplar were taken from stems raised in a very favourable locality. Here again no opportunities have been available for furnishing data concerning the Elm when grown on land of the I. or III. quality.

The details for the Black Poplar only apply to land of good quality (No. I.), as average or inferior land is more usually planted up with less exacting kinds of trees.

The girth measurements recorded concerning the Beech and the Sweet Chestnut were taken from the average of a number of trees cut down on various estates in Mid-Lothian, where they were growing on moderately favourable soils and situations.

From the statements given relative to the periodical increase of timber in the Sweet Chestnut and the Beech, it is observable that, on a soil of moderate productive capacity, the Beech grows to a much larger size than the Sweet Chestnut. This shows that, in order to attain the large dimensions found in some parts of the country, the Sweet Chestnut requires a favourable soil and situation. This is a point of great importance to be kept in view in valuing wood for the transfer of property.

All the measurements referring to Larch were taken from trees cut on the estate of Arniston. They indicate that, on a favourable soil and situation, the Larch will continue in active growth till above 80 years of age, and will even then be of a sound constitution, as the author frequently had occasion to observe. But, on a soil of only moderate productive capacity, 60 years may be considered as the best age for utilising the Larch; hence, in order to have the best returns from the trees growing on land of that description, they should then be cut down. Again, upon soil and situation that appear unfavourable, from 30 to 35 years may be considered as the best age for the felling of the trees; for, if not cut down at that age, the trees will probably begin to decay rapidly in the heartwood.

The data regarding the Scots Pine were taken from measurements made in the Highlands of Scotland, as well as others collected on several other properties in the North.

Details with regard to the Spruce were taken from an average of trees measured on a number of estates in Mid-Lothian.

The measurements referring to the soil and situation classed as of the I. quality were taken from trees generally growing in hollow sheltered parts upon a stiff heavy clay of a moist tenacious nature; those in Column II. were from trees generally growing upon a fair

loamy soil on flat parts of the country, well drained; whilst those in Column III., referring to unfavourable soil and situation, have all been taken from the average of trees found growing upon a thin gravelly soil with a high exposure. Under the latter circumstances Spruce seldom arrives at any useful size, as heart-rot generally begins to make its appearance at from 30 to 35 years of age; and then the trees have to be cut down in order to save total loss.

The details referring to the Birch were taken from the average of a large number of trees felled on the Bute estate, on moderately favourable soils and situations. The most favourable time for felling the Birch is between 40 and 60 years of age, as it then yields larger average annual returns than at any other time.

The details referring to the Silver Fir were the results of measurements made on a large number of trees felled on the Bute estate on moderately good soils and situations. They show that the common Silver Fir, when grown on a moderately favourable soil and situation, and when of 10 years' standing, is fully larger in the diameter of its stem than Spruce Fir growing under similar circumstances. The latter, at 8 ft. above the ground, is only 1 in. in diameter, whilst the former is 1½ in. The rapid growth of the Silver Fir is very observable between 10 and 20 years, and even up to 60, when, on a moderate soil, its diameter exceeds that of the Spruce at the same age, even though the latter be found growing on favourable soils and sites. Another remarkable feature in the Silver Fir is that it continues to grow in girth to a much greater age than the Spruce does. The latter appears in Britain almost to cease to increase in diameter after it has attained the age of from 80 to 85 years, while the former grows and adds considerable layers of wood even up to 110 years.

The foregoing statements relative to the periodical growth of the principal forest trees were found by the author to be of great assistance when he was called out to value plantations prospectively for the transfer of landed property. They are, however, merely a contribution towards the compilation of more general, and therefore more reliable, data. There is a great want of a far more extensive basis upon which to calculate the progressive growth of trees than is here given; and it would be of infinite advantage to all interested in timber-growing were every intelligent forester to turn his attention to this point, and to lay up, at least for himself, from his own experience, as extensive data as possible relative to the periodical increase in the growth of the timber on the estate upon which he may be employed.

The system adopted by the author of giving the diameters only at 8 ft. above the ground is open to the objection that, for every-day purposes, such a height is practically impossible of attainment by the forester whenever he may wish to take the measurement of standing timber. The idea presum-

ably was to get rid of all the buttressed or thickened portion of the butt end of the stem; but in Germany any difference in calculation is easily overcome, with a close approach to accuracy, by the application of a **Form-factor**, fixed by a vast number of actual measurements in crops of different quality growing on different classes of soil.

So far as data are available concerning the **basal area or stem-section** of different kinds of individual trees growing in the close canopy of woodlands of normal density, the only convenient data are those that were compiled in 1892 by the editor for his *British Forest Trees*. They are there exhibited on p. 41 as under—

"The *Mean Diameters at Breast-Height*, reckoned from the sources already named, have been calculated to be as follows (in inches):—

Age of forest.	Beech.		Silver Fir.		Spruce.		Scots Pine.	
	Soil quality.		Soil quality.		Soil quality.		Soil quality.	
Years.	I.	V.	I.	V.	I.	IV.	I.	IV.
40	4.0	...	5.2	2.0	5.6	Data not available.	6.4	2.8
60	7.6	3.2	9.2	4.0	9.2		9.6	4.4
80	10.0	4.8	12.8	6.4	12.0		12.0	5.6
100	11.6	6.8	15.6	8.0	14.0		17.2	...
120	13.6	8.4	17.6	9.6	15.2		18.0	...

The reason for this apparent paucity of details regarding the rate of development of the girth of individual stems in plantations is that on the Continent the **units of consideration** are not the height, and the girth, and the cubic contents of the individual stems forming the crop, but the average height, and average girth, and average cubic contents of the whole crop per hectare (2·47 acres).

The difference between the two methods of estimating the thriving of the woodland crops is, in fact, precisely what might be expected from our **arboricultural** way of looking at trees as compared with the **sylvicultural** method of treating forests on the Continent. There all sylvicultural crops are measured with respect to girth at breast-height, *i.e.*, 4½ ft. above the ground.

III. Rate of Growth in Cubic Contents or Total Increment.—The growth of any crop in cubic contents is merely the resultant or final expression of its energy with regard to growth in height and growth in girth combined. It is, of course, like each of these specific forms of vegetative activity, more energetic on soils that are of good general quality than on poorer descriptions of land. Hence, whilst the average annual increment of the crop culminates earlier on inferior soil, the progressive profitable development of woodland trees is of longer duration, the more the soil and situation are suited to the natural requirements of the kind or kinds of trees forming the crop. In other words, on the better classes of land there will not only be a larger outturn in timber per acre at any given age than from poor land, but at the same time longer periods of rotation may be employed, *i.e.*, the fall of the mature timber will not, by purely financial calculations, be indicated at so early an age as on woodland tracts of an inferior description.

Wherever woods are crowded, that is to say, exceed the normal density of canopy, then growth in height is stimulated at the expense of growth in

girth; and when the individual growing-space is larger than there is any necessity for, then growth in girth takes place at the expense of growth in height for each individual stem forming the crop. There must consequently be a certain point—varying, of course, in each crop according to the nature of the soil and situation, the kinds and ages of the trees, &c.—or **normal density of canopy** which unites the maximum length of stem with the maximum mean girth of bole, so as to produce the maximum cubic contents per acre that can possibly be expected from the land in question. And the maintenance of a normal density of canopy has also other advantages in the way of forming a more full-wooded bole, *i.e.*, a stem having a better proportion of top-girth to basal area, and of maintaining the productive capacity or fertility of the soil against insolation and exhausting winds.

There is, throughout Great Britain and Ireland, a great tendency on the part of foresters to estimate the cubic contents and market value of individual stems, and then to calculate the number of stems per acre so as to arrive at the value of the crop. On the Continent the more practical method is adopted of calculating the yield per acre; for the height and the girth of growing crops practically in most cases rise and fall with the gross cubic contents per acre. And the same may be said of the value of the crop per unit of measurement.

Such **Tables of Average Yield** give in reality a much better general standard to judge by than that adopted in the British method; and it is more with a view to lead to the formation of such tables, than for any direct local application that will be possible, that the following data for Hanover, taken from Burckhardt's *Hülfstafeln*, and based on very extensive fellings and measurements, are brought to the notice of British foresters. Where they may be used for comparison with any existing circumstances, it must be borne in mind that they can be approximations merely. They cannot have anything like the same authority as if they had been compiled from actual data furnished from our own home-grown woods.

HIGH-FOREST OF OAK;[1] *Total Cubic Contents above the Soil.*

Height of crop.		Density of leaf-canopy.			
		I. Full.	II. Fairly good.	III. Rather light.	IV. Light.
	Feet.	Cubic ft.	Cubic ft.	Cubic ft.	Cubic ft.
Very good .	90–110 or more	10,200–9,300	8,400–7,500	6,750–6,000	5,700–4,950
Good . . .	80–95	8,700–7,950	7,200–6,450	5,700–4,950	4,800–4,200
Average . .	70–85	7,500–6,750	6,000–5,400	4,800–4,200	4,050–3,450
Below average .	60–75	6,000–5,400	4,800–4,200	3,900–3,300	3,150–2,550
Inferior . .	50–65	4,800–4,200	3,900–3,300	3,000–2,400	2,250–1,800

[1] Absolute accuracy has not been aimed at by the editor in transforming Burckhardt's data into British measure; the tables are approximate only.

Thus the hectare = 2.471 Acres = 3.815 Hanoverian Morgen.

∴ 1 acre = 1.544 Morgen.

Again 1 cubic metre = 35.316 cubic ft. British measure = 40.126 cubic ft. Hanoverian measure.

∴ 1 cubic ft. British measure = 1.13 cubic ft. Hanoverian measure.

In transforming the tables, the editor has simply increased the data by 50 per cent., as being quite approximate enough for the end in view.

The following note will explain the classification of the crops as to their **Density of Canopy**:—

I. Includes full-canopied, good, mature crops that have grown up in normal leaf-canopy, and comprises what one would, in a general way, call very good canopy.

II. Includes mature crops growing in fairly good canopy, but yet not so good as in the previous class. It also comprises denser crops that are only approaching their full maturity, and the better classes of mature plantations originally formed on grazing land at distances of 14 to 16 ft. from plant to plant.

III. Includes wide plantations, or similar crops having large crowns forming a fair canopy, now mostly mature. It also comprises younger crops of the better class that have grown well in height, and are now partially cleared for the purpose of thickening more rapidly in girth.

IV. Includes thin crops of backward growth that are mature, and also old wide plantations having a broken canopy and a weak annual increment. The branch-wood varies from 4 to 7 per cent. of the total crop, and may even amount to about 10 per cent.

HIGH-FOREST OF BEECH; *Total Cubic Contents above the Soil.*

Height of crop.		Density of leaf-canopy.				
		I. Dense.	II. Full.	III. Fairly good.	IV. Rather light.	V. Light.
	Feet.	Cubic ft.	Cubic ft.	Cubic ft.	Cubic ft.	Cubic ft.
Very good .	100 or more	10,500–9,750	9,450–8,700	8,250–7,500	...	...
	90–100	9,000–8,250	8,250–7,500	7,200–6,600	...	...
Good	80–90	8,250–7,500	7,200–6,450	6,300–5,700	5,400–4,800	4,500–3,900
Average . . .	70–85	7,200–6,600	6,300–5,550	5,400–4,800	4,500–3,900	3,900–3,300
Below average.	60–75	5,700–5,100	5,100–4,800	4,500–3,900	3,900–3,300	3,300–2,700
Inferior . . .	50–65	4,500–3,900		3,900–3,300	3,300–2,700	2,400–1,800

The above classification as to **Density of Canopy** is as follows:—

I. Includes mature crops on good soil, in the full vigour of growth, and having well-shaped stems. It also comprises all ordinarily full, or even somewhat thin, crops of advanced age.

II. Includes all ordinarily good crops of normal density, good mature woods on less favourable kinds of soil, and woods approaching maturity on land well suited to the Beech.

III. Includes mature crops that have a fairly good density, as well as full crops of rather indifferent growth, or only beginning to approach maturity. It also comprises full crops in which many of the trees have sprung from stool-shoots, or in which the trees vary considerably in age, and consequently in size, also close-canopied crops, consisting of large stems with broad crowns, growing on good soil.

IV. Includes old crops, mostly deficient in increment, or old copse that is being transformed into high-forest.

V. Thin, old, poorly-grown crops; thinly-stocked woods of moderate age; or old, senile trees formerly forming copse, &c.

The branch-wood can, on the average, be reckoned as about 10 per cent. of the total quantity. In the better classes of stems, of greatest height, it ranges from about 8 to 10 per cent.; whilst in the other classes it varies from 10 to 12 per cent., and may even amount to 14 per cent.

SPRUCE FOREST; *Total of Wood in the Stem.*

Height of crop.		Density of leaf-canopy.		
		I. Dense.	II. Fairly good.	III. Light to thin.
	Feet.	Cubic ft.	Cubic ft.	Cubic ft.
Very good . . .	100–120 or more	12,000–10,800	9,900–9,000	7,500–6,600
Good	90–110	10,500–9,600	8,700–7,800	6,600–5,700
Average . . .	80–95	8,400–7,500	6,900–6,000	5,250–4,500
Below average . .	70–80	6,300–5,700	5,255–4,500	4,050–3,450
Inferior . . .	55–65	4,950–4,500	3,900–3,300	3,300–2,700

The above classification as to **Density of Leaf-Canopy**—

I. Includes mature crops forming really good canopy, or even somewhat aged crops that may not be very dense, but are tall and full in the stem.

II. Includes ordinary good mature crops, and full crops approaching maturity.

III. Includes thinner mature crops, and good dense crops of from thirty to fifty years of age.

Wherever there are any large windfall areas, they must, of course, be deducted from the acreage when making the calculation as to the growing crop of wood. These figures, likewise, do not apply to groups of trees or patchy crops at lofty elevations, but are intended for large masses of woodland growing on soil of the ordinary classes for this kind of tree.

About 3 to 5 per cent. of the total quantity consists of branch-wood of about 1 in. or more in diameter.

SCOTS PINE FOREST; *Timber only (above 2 in. in diameter).*

Height of crop.		Density of leaf-canopy.			
		I. Full.	II. Fairly good.	III. Rather light.	IV. Light.
	Feet.	Cubic ft.	Cubic ft	Cubic ft.	Cubic ft.
Very good .	90–100 or more	9,000–8,250	8,250–7,500	6,750–6,000	5,250–4,500
	80–90	7,500–6,750	6,750–6,000	5,250–4,500	4,200–3,600
Good . .	70–80	6,300–5,700	5,400–4,800	4,500–3,900	3,300–2,700
Average .	60–70	5,100–4,500	4,200–3,600	3,600–3,000	2,700–2,250
Below average	50–65	4,200–3,600	3,300–2,700	2,700–2,250	2,100–1,800
Inferior .	30–40	2,700–2,250	1,950–1,500	1,500–1,200	1,200–900

This classification with regard to the **Density of the Leaf-Canopy**—

I. Includes full, mature, or nearly mature crops growing in really good canopy; also somewhat thinner, but older, crops growing on land of good quality, and having stems of particularly good development.

II. Includes fairly full crops, that may be classifiable as forming good canopy on the whole—and crops of satisfactory growth on land of only moderate quality, before the latter have become too old and consequently thin.

III. Includes crops that are decidedly thin. Such comprise, among others, crops formed of seed shed from a distance, which have grown up more or less in patches and groups, of different height and age—woods that have been slightly interrupted in canopy through insect attacks, snow-break, &c.—and older crops on unfavourable soil or situation that have become broken in canopy. These latter, however, frequently belong to IV.

IV. Very light-canopied and thinly-stocked crops. These comprise woods that have been considerably damaged by insects, or have become broken in canopy, owing to advancing age, on land of a poor description—thin crops formed of seed blown across from other woods, &c.

In the above table very badly grown crops on poor, barren moorland, or on moorpan soil, are not included.

The natural thinning of the canopy which takes place in Scots Pine woods does not prevent the results set forth in I. and II. being obtained, so long as the age of the crop is not too great.

Mixed crops of Spruce and Scots Pine are very frequently classifiable under column I. of the above table.

For small branch-wood from 5 to 8 per cent. may be added to the above outturn. Burckhardt (*op. cit.*, p. 200) gives the following very convenient table for the average annual increment in different kinds of forest-crops throughout the Hanoverian forests that were under his charge:—

TABLE SHOWING THE AVERAGE ANNUAL INCREMENT IN TIMBER CROPS.

Kind of tree and method of treatment.	Quality of the soil and situation.					Age at maturity.	
	I.	II.	III.	IV.	V.	I. & II.	IV. & V.
HIGH-FOREST.	Cub. ft.	Cub. ft.	Cub. ft.	Cub. ft	Cub. ft.	Years.	Yrs.
Oak	75–66	66–57	57–49½	49½–45	42–37½	160	120
Beech	82½–75	72–63	61–54	54–45	45–37½	(140) 120	90
Beech with Spruce, &c.	...	...	...	66–60	60–54	...	100
Spruce	120–108	105–93	90–79½	72–63	55½–48	120	70
Scots Pine	93–78	75–60	60–49½	48–39	33–27	(120) 100	60
Birch	97½–85½	78–67½	55½–46½	33½–24	16½	60	40
Alder	82½–75	67½–60	52½–45	...	...	70	50
COPSE.							
With many Beeches, &c., in the overwood, and Hardwoods as underwood	90 (97½)	75	63	51	39 (30)	30	35
With Oaks, &c., as standards, and a mixture of Hardwoods and Softwoods as the Coppice	67½	60	52½	45	36	18	25
COPPICE.							
Oaks or Hornbeams, mixed with other Hardwoods, and with Hazel, &c.	69 (75)	60	51	40½	30–27	15	20
Alders (marshy land)	99–93	84–78	67½–60	48–39	30–22½	25	35
Birches, pure or predominating	82½–75	72–63	60–51	48–42	36–30	20	30

It will be observed that in **High-Forest** the longer period of rotation occurs on the better classes of land, whilst in **Copse** and **Coppice** the shortest periods of rotation are only permissible on good soils and situations. This means that on better classes of woodland soil the capital, represented by the land plus the growing stock of timber, in a high-forest will continue to show good profits for a longer time than can be yielded by poor land. In the case of coppice, however, a clearance of the hags every fourteen to sixteen years is only admissible on really good land; whereas considerations regarding the continuous productive capacity of the soil demand a longer period of sixteen to eighteen, or even twenty years in less favourable situations.

Valuation of Growing Timber Crops.—The valuing of plantations is a branch of Forestry which, to be treated properly and justly, requires the exercise of the judgment of a man who has had long practical experience in the matter. He who gives himself out as a valuator of plantations, in the settlements and divisions of landed property, must be possessed of an accurate knowledge of the prospective value of all the plantations that can possibly come under his notice, under the age of full-grown timber. He must have an intimate knowledge of the habits of growth of the different species of forest-trees, and of the influence of soil and local climate on their periodical increase in timber. These qualifications are absolutely necessary in the valuing of young plantations while they are under the age of full-grown timber trees; and they are only attainable after a long course of experience.

In taking the present transferable value of plantations, they may be divided into three different and distinct classes, namely—

I. Plantations not thinned for the first time.
II. Those which have been thinned, but are under full-timber size.
III. Those of full-timber size.

Each of these three classes is, throughout Britain, valued in a manner different from either of the others. With regard to the first, in estimating the transferable value of any young plantation which has not been thinned for the first time, the original expense of fencing, draining, and planting would in the first place be calculated; and after this had been ascertained, the extent of the plantation in acres would next be measured, and a fair rent fixed for it per acre. This annual rental value should correspond with that of the same quality and condition of land in the immediate neighbourhood; but in all cases an allowance should be made for inaccessible heights and hollows. Then the rule for finding the valuation is—to the cost of fencing, draining, and planting, and the rent of the land occupied for the time, add the amount of compound interest on these,

at from 3 to 5 per cent., according to the state of the crop, and the result will indicate a fair transferable value between the two parties.

In Scots Law, under the Valuation of Lands Act, 1854, § 6, in estimating the yearly value of lands and heritages, the same shall be taken to be the rent at which, one year with another, they might in their actual state be reasonably expected to let from year to year.

Where they consist of woods, copse, or underwood, the yearly value shall be taken to be the rent at which they might in their natural state be reasonably expected to let from year to year as pasture or grazing lands (Bell's *Dictionary and Digest of the Law of Scotland*, 1890, pp. 1106).

The above method of estimating the present value of growing crops is that known on the Continent as the **Cost of Production.** There are practically three methods of arriving at the value of woodland crops, viz.:—

I. Assessment of the cost of production, calculated at compound interest up to date.

II. Assessment of the prospective value, discounted at compound interest down to date.

III. Assessment of the current market value, on the basis of sales made recently.

This is a subject the full discussion of which would occupy a volume by itself; hence only general principles can be indicated here.[1] As an example of the method of calculating the cost of production of woodland crops, the following may be quoted from the editor's *Studies in Forestry*, 1894, pp. 2 and 3, concerning the British woodlands, whose area extends to 3,005,670 acres:—

"But taking a rotation of about 90 years as the average, and that would certainly not be too high an one, this would mean that the present market value of the timber-crops on these three millions of acres of woods (assuming that they range normally from 0 to 90 years of age) is equal to 3,000,000, multiplied by the average quantity of timber contained in crops 45 years of age, or equal to 1,500,000 acres multiplied by the average quantity of timber yielded by a mature crop of 90 years in age. . . .

"At the very lowest computation, *the actual cost of production of the timber-crops*, which, even under management of an unsatisfactory economic nature only, must be far below their true market value, equals

$$\left(\begin{array}{l}\text{(annual rental of 3,000,000 acres)}\\ \qquad + \text{costs of forming or regenerating 3,000,000 acres}\end{array}\right) 1.0\, r^{\frac{90}{2}}$$

where r = the rate per cent. at which the proprietor is content to lock up his capital represented by soil plus growing stock. If the sylvicultural soil were of equal productive power with that utilised agriculturally, then it would be necessary to estimate r at a higher rate than is permissible in actuarial calculations relating to farming, owing to the greater risk run by forest crops from wind, fire, insects, &c., before attaining their financial maturity. Thus, in Central Germany, whilst the rate of interest for ordinary investments is about 3½ to 4½ per cent., that for actuarial calculations referring to agricultural soil ranges from 2 to 3 per cent., and for State Forest land it may be put at 2 to 2½ per cent.; but rates varying

[1] See also vol. i. chap. i. pp. 42 and 58.

from 2½ to 3½ per cent. are laid down in laws referring to expropriation of forest areas, whilst Pressler insists that it should be 3½ per cent. for State Forests, 4 per cent. for large landowners, and 4 to 5 per cent. for smaller proprietors working on more purely financial principles. Owing, however, to the extrinsic appreciation in the value of broad acres, as conferring a certain degree of social elevation among the moneyed classes in Britain, so low a rate as 2½ per cent. may perhaps be taken for the purpose of determining the actual minimum cost of production of our growing-stock of timber. Taking the annual average rental of the land at about 5s. an acre, and the cost of forming or regenerating the crop at £2 an acre (which was the sum named by Mr Macgregor in his evidence before the Committee on Forestry on June 28, 1887, as the cost of planting Scots Pine in the Athole forests in Perthshire), the actual cost of production of our woodlands at the present time will therefore be

$$(3{,}005{,}670 \times £2\ 5s.)\ 1.025^{45} = £20{,}544{,}571.$$

This does not take into consideration intermediate returns from thinning, &c., but, *per contra*, it omits all annual charges for administration, protection, and rates chargeable. And this is only the *actual cost of production*, whilst the *prospective value of the mature crops* is in reality a very much greater sum."

The leading points with regard to the **Valuation of Forests** may be briefly indicated in the following paragraphs. A few illustrations are also added which the reader will have to work out for himself by the use of one or other of the formulæ given.

Valuation of Forests is that branch of Forestry which treats of the monetary value of forests as representing a capital bearing interest. It teaches how we can estimate the value—

1. Of the soil.
2. Of the growing stock.
3. Of the forest; and
4. Of the annual returns from soil, stock, and forest.

Under **Forest** is here understood the sum total of soil plus growing stock.

Methods of Valuation.—A forest may be valued according to—

1. Its *present Prospective Value*—that is, its prospective nett value (exclusive of costs of production) discounted to the present, *i.e.*, its discounted future nett value.
2. Its *Cost of Production*—that is, the actual expenditure necessary to produce it.
3. Its *Market Value*—that is, the actual monetary sum usually obtained when similar estates are sold, or
4. Its *Capitalised Value*, expressed by the formula $C = \frac{100\,r}{p}$, in which C represents the capital requisite to produce the annual return r at a given percentage of interest p, thus—

$$C : r = 100 : p$$
$$\therefore C = \frac{100\,r}{p}$$

All money—whether consisting of capital only or of interest only, or of capital plus interest—possesses the inherent capacity of bearing interest; hence, in calculations concerning the valuation of forests, all reckoning must

be by means of compound interest only. Calculation by means of simple interest merely would mean that only the capital should be considered capable of bearing interest, and not the annual increments made to the capital in the nature of interest. This would be open to the following objections:—

1. It would rest on false premises, contradictory to the true nature of money.

"Simple interest is almost a fiction; the moment any sum of money is due, it matters not whether it be called principal or interest, it is of equal value to the owner."[1]

2. It leads to inapplicable results in the determination of the capitalised value of continuous regular returns—viz., that the present value of perpetual fixed returns is less than that of similar regular returns fixed for a period only, which is absurd.

Formulæ for Computation of Present and Future Values by Means of Compound Interest.[1]—The following comprise the formulæ requisite for the calculations as to the assessment of the cost of production, or the discounting of the prospective value, &c.

1. *Computation of Future (prolonged) Value, F,* of a capital C invested for n years at an interest of p per cent.

$$F = C \times 1.0\, p^n$$

2. *Computation of Present (discounted) Value, P,* of a future return F, accruing once after n years, interest being reckoned at p per cent.

$$P = \frac{F}{1.0\, p^n}$$

3. *Computation of Future Value of Returns:*[2]—

(*a.*) *Periodic Returns.*—A return r, accruing for the first time after m years, and then again for n times after periods of every m years, attains up to the end of $m \times n$ years the summarised value F_v.

$$F_v = \frac{r\,(1.0\, p^{mn} - 1)}{1.0\, p^m - 1}$$

(*b.*) *Annual Returns.*—A return r, accruing regularly at the end of each year, and for n times in all, attains up to n years the summarised value F_v.

$$F_v = \frac{r\,(1.0\, p^n - 1)}{1.0\, p - 1} = \frac{r\,(1.0\, p^n - 1)}{0.0\, p}$$

This formula is in reality identical with that for periodic returns, as $m = 1$.

---

[1] A study of Todhunter's *Algebra*, pp. 336–353, dealing with problems regarding interest, equation of payments, and annuities, is recommended to the student.

[2] These calculations are all based on the general formula for geometrical progression,

$$S = a + aq + aq^2 + \ldots\ldots + aq^{n-1} = a\,\frac{q^n - 1}{q - 1} \text{ or } = \frac{1 - q^n}{1 - q}.$$

4. *Computation of Present Value of Returns:—*

(*a.*) *Terminable Returns:—*

(1.) *Periodic.*—The capitalised present value P_v of a return accruing for the first time after a years, and then regularly after periods of m years, for n times altogether, is (at the commencement of a)

$$P_v = \frac{r\,(1.0\,p^{mn} - 1)\;1.0\,p^{m-a}}{(1.0\,p^{m} - 1)\;1.0\,p^{mn}}$$

When it accrues at regular intervals of m years ($m = a$), and for n times in all, its value is

$$P_v = \frac{r\,(1.0\,p^{mn} - 1)}{(1.0\,p^{m} - 1)\;1.0\,p^{mn}}$$

(2.) *Annual.*—When it accrues annually ($m = a = 1$) for n years in all, its value is

$$P_v = \frac{r\,(1.0\,p^{n} - 1)}{1.0\,p^{n} \times 0.0\,p}$$

These last two formulæ are practically identical with the first, as in the one case $m = a$, and in the other $m = a = 1$.

(*b.*) *Continuous, Interminable, or Perpetual Returns:—*

(1.) *Periodic.*—The capitalised present value P_v of a return accruing for the first time after m years, and then continuously after every n years, is

$$P_v = \frac{r\,(1.0\,p^{n-m})}{1.0\,p^{n} - 1}$$

When it accrues immediately, and regularly afterwards every n years, then

$$P_v = \frac{r\,(1.0\,p^{n})}{1.0\,p^{n} - 1}$$

(2.) *Annual.*—When it accrues annually ($m = n = 1$ in first equation),

$$P_v = \frac{r}{0.0\,p}$$

5. *Transmutation of a Periodic into an Annual Return:—*

(*a.*) If the return R accrues every n years from now, the equivalent annual return r is

$$r = \frac{R}{1.0\,p^{n-1} - 1} \times 0.0\,p$$

(*b.*) If R accrues first after m years, and afterwards every n years, then

$$r = \frac{R \times 1.0\,p^{n-m}}{1.0\,p^{n} - 1} \times 0.0\,p$$

(*c.*) If R accrues immediately, and again after every n years, then

$$r = \frac{R \times 1.0\,p^{n}}{1.0\,p^{n} - 1} \times 0.0\,p$$

For comparison and ready reference these various formulæ may conveniently be grouped together in the following classification :—

ABSTRACT OF FORMULÆ.

Future value.	Basis of reckoning.	Present value.
$F = C \times 1.0p^n$.	Capital.	$P = \frac{F}{1.0p^n}$.
	Income or returns r.	
	(a) terminable.	
$F_v = \frac{r(1.0p^{mn} - 1)}{1.0p^m - 1}$	(1) periodic.	
	(α) accruing first after m years.	$P_v = \frac{r(1.0p^{mn} - 1)1.0p^{m-a}}{(1.0p^m - 1)1.0p^{mn}}$
	(β) accruing at once and every n years.	$P_v = \frac{r(1.0p_{mn} - 1)}{(1.0p^m - 1)1.0p^{mn}}$
$F_v = \frac{r(1.0p^n - 1)}{0{\cdot}0p}$	(2) annual.	$P_v = \frac{r(1.0p^n - 1)}{1.0p^n \times 0.0p}$
	(b) continuous or interminable.	
$F_v = \infty$	(1) periodic.	
	(α) accruing first after m years.	$P_v = \frac{r(1.0p^{n-m})}{1.0p^n - 1}$
	(β) accruing at once and every n years.	$P_v = \frac{r(1.0p^n)}{1.0p^n - 1}$
$F_v = \infty$	(2) annual.	$P_v = \frac{r}{0.0p}$
	Transmutation of periodic returns R into an annual return r.	
	(1) R accruing every n years from now.	$r = \frac{R}{1.0p^{n-1} - 1} \times 0.0p$
	(2) R accruing first after m years and then every n years.	$r = \frac{R \times 1.0p^{n-m}}{1.0p^n - 1} \times 0.0p$
	(3) R accruing immediately and then every n years.	$r = \frac{R \times 1.0p^n}{1.0p^n - 1} \times 0.0p$

The Determination of a Suitable Rate of Interest is dependent on three factors—

1. The relation between supply and demand as regards capital.
2. The degree of safety of the investment.
3. The regularity and convenience with which the returns are obtained.

In Forestry the percentage is lower than the average market rate of interest on ordinary investments for the following reasons :—

1. Because forests (soil plus growing stock) give better guarantee for the security of the capital than ordinary investments.
2. Because experience proves that the value of forest products has been steadily increasing, whilst the value or purchasing power of money has been sinking.

3. Because woodlands, like landed property in general, are not capable of being increased to any indefinite extent, but must belong to the few on whom they confer a certain amount of prestige and social status.
4. On account of various amenities derivable from forests, *e.g.*, shooting, fishing, &c.

It is, however, by no means a constant quantity, being subject to fluctuations in the general value of landed estate.

In comparison with agricultural investments, Forestry has much in common; still there are numerous points of difference. These are:—

Advantages, tending to increase the comparative rate of interest in calculations concerning Forestry:—

1. Less labour and supervision are required in Forestry than in agricultural operations involving the sinking of the same amount of capital.
2. A working-plan can be framed for a forest so as to yield constant annual returns; whereas the agricultural harvest varies in quantity year by year, and often to a very considerable extent.
3. The possibility of utilising an advantageous market by heavy fellings, or of storing up produce when prices are low.

Disadvantages, tending to reduce the comparative rate of interest to be reckoned:—

1. For a long time after the formation of forests, no returns, or only very slight ones, are obtainable.
2. The enhanced risk of loss from organic or inorganic causes is extended over much longer periods in Forestry than in agriculture.
3. The average annual returns from agriculture are more easily determined than those from forests.
4. Forests cannot be leased out like agricultural lands without great risk to the proprietor.

Agricultural returns are determined mostly by increased demands, forest returns by diminishing supply.

As regards security of investment, the annual increment in forests may for several years be injuriously affected by insects, or the sum total of the annual increments may even be destroyed by fire; whereas in agriculture the damage is confined to the crop for the year. It would be wrong, however, to conclude from these possibilities that the actual danger is greater in Forestry than in Agriculture. But enough has been shown to prove that the agricultural rate of interest cannot be applied as a matter of course to actuarial problems in Forestry. Taking the general market rate of interest at 4 per cent., the agricultural rate ought to be about 3–3½ per cent., and that in Forestry (1) about 2½–3 per cent., in the case of forests with long periods of rotation, and consisting of species of trees not exposed to special dangers (*e.g.*, mixed forests of Beech, Oak, Maple, Ash, &c.), (2) somewhat higher, say 3–3½ per cent., in regard to Conifers, more liable to damage from insects and from fire, and (3) still more so, 4–5 per cent., in the case of coppices of Oak, Willow, &c., worked on short periods of rotation.

When an actual purchase of forest takes place, the rate of interest at which the proprietor is content to work is at once found from the formula—

$$\text{Total cost} : \text{annual returns} = 100 : p$$

$$\therefore p = \frac{\text{annual returns}}{\text{total cost}} \times 100.$$

Practically speaking, good soil yields a better return when given up to agriculture, poor soil when stocked with forest.

Computation of the Costs Incurred in Forestry, and the Returns Yielded.—The following expenditure has to be estimated or determined :—

1. Cost of administration and supervision.
2. Cost of sowing, nurseries, planting, &c.
3. Cost of harvesting or realising the forest produce.
4. Cost of erecting and maintaining boundaries.
5. Cost of making and maintaining roads, transport paths, &c.
6. Cost of taxes and burdens on the land.

The returns are as follows :—

1. **Timber**, estimated either by actual measurement, or by average yield tables for different species of trees, and graded according to different qualities of soil. The value of the timber must be assessed by local averages, or by those of elsewhere, less costs of transport. The possibility or probability of any change in prices should be noted; and it should be borne in mind that the general tendency has hitherto been for timber to rise steadily in value, whilst money has declined in purchasing power.

2. **Minor Produce**, including shooting, fishing, quarrying of stone, tapping of resin, barking of trees before felling, grazing, leaf-mould, &c. These may be estimated according to average local rates; but it is to be noted that excessive utilisation of minor produce frequently reacts injuriously on the outturn in timber.

A Few Actuarial Examples.—*In the following examples the rate of interest is taken as 3 per cent.* :[1]—

1. By how much must the returns from a coppice, that is worked with a rotation of twenty years, rise before an outlay of 50s. in cultural improvements will prove profitable?

$$50 \times 1.03^{20} = \text{£4 10s. } 3\tfrac{3}{5}\text{d.}$$

2. At the end of the period of rotation, what is the total value of all the returns from this coppice-wood per acre, if for every 2.47 acres the following revenue be obtained :—

(*a.*) Final yield = £50, less costs of felling.
(*b.*) Thinning during the twelfth year = £5.
(*c.*) Annual value of shooting = $\frac{3}{5}$ of 1s.
(*d.*) Agricultural utilisation of the soil for the first two years = £1.

Calculated all in shillings as a common denominator, this gives—

$$1000 + 100.103^{3} + 0.60\frac{1.03^{20} - 1}{0.03} + 20\frac{1.03^{2} - 1}{0.03}.1.03^{18}$$

$$= 1000 + 126.68 + 16.12 + 69.12 = 1211.92 \text{ shillings for 2.47 acres}$$

$$= \text{£24 10s. } 7\tfrac{4}{5}\text{d. per acre.}$$

3. What is the present prospective value of all these returns at the commencement of the period of rotation?

$$\frac{1000}{1.03^{20}} + \frac{100}{1.03^{12}} + 0.6\frac{1.03^{20} - 1}{1.03^{20} \times 0.03} + 20\frac{1.03^{2} - 1}{0.03 \times 1.03^{2}}$$

$$= 553.7 + 70.14 + 8.93 + 38.27 = 671.04 \text{ shillings for 2.47 acres}$$

$$= \text{£13 11s. 8d. per acre.}$$

[1] These illustrations are taken from Wimmenauer's *Grundriss der Waldwerthrechnung*, 1891, pp. 35 and 65.

4. What is the present prospective value of all returns from the same throughout a whole century, supposing that they continue as at present?

$$1211.92 \frac{1.03^{100} - 1}{1.03^{100}(1.03^{20} - 1)} = 1424.30 \text{ shillings for } 2.47 \text{ acres}$$
$$= \textbf{£28 16s. } 7\tfrac{7}{10}\textbf{d. per acre.}$$

5. And, under the same proviso, what is the present prospective value of all the returns *in perpetuo?*

$$\frac{1211.92}{1.03^{20} - 1} = 1503.4 \text{ shillings for } 2.47 \text{ acres} = \textbf{£30 8s. 8d. per acre.}$$

From 4 and 5 it will be noted that the value of all returns from the commencement of the second century onwards is only 5.3 per cent. of the total amount of the present prospective value of the returns during the first 100 years.

6. But if the coppice-wood has first to be formed by sowing or planting, for which a first rotation of thirty-two years may be necessary before the crop can be advantageously cut, how would this affect the calculation in the case of example No. 2?

$$\frac{1211.92 \times 1.03^{-12}}{1.03^{20} - 1} = \frac{1503.40}{1.03^{12}} = 1054.50 \text{ shillings for } 2.47 \text{ acres}$$
$$= \textbf{£21 6s. } 9\tfrac{1}{4}\textbf{d. per acre.}$$

7. In the case of example No. 6, how would the present prospective value of all expenditure be affected if the outlay amounted to—

(*a.*) £5 for the cultural costs on the first occasion, and £2 10s. 0d. on each subsequent occasion?

(*b.*) £0 4s. 6d. for every 2.47 acres for costs of protection, administration, land-rate, &c.?

The present prospective value of the nett profit would be—

$$100 + 50 \frac{1.03^{-12}}{1.03^{20} - 1} = \frac{4.5}{0.03} = 100 + 43.5 + 150$$

$$= 293.5 \text{ shillings for } 2.47 \text{ acres} = \textbf{£5 18s. } 9\tfrac{3}{5}\textbf{d. per acre.}$$

8. What would the present prospective value of all nett returns consequently be, and what nett annual income would be represented by the clearing of the coppice periodically?

$$1054.5 - 293.5 = 761 \text{ shillings for } 2.47 \text{ acres} = \textbf{£15 8s. 1d. per acre.}$$

This would be equivalent to an annual income of

$$£15 \text{ 8s. 1d.} \times 0.03 = \textbf{£0 9s. } 2\tfrac{3}{4}\textbf{d. per acre.}$$

9. How high would these same returns be, if calculated only from the commencement of the second period of rotation?

The present prospective value of the nett returns would be—

$$1503.4 - (50 + 62.02 + 150) = 1241.38 \text{ shillings for } 2.47 \text{ acres}$$
$$= \textbf{£25 2s. } 6\tfrac{4}{5}\textbf{d. per acre.}$$

And the annual nett income would have a value of

$$£25 \text{ 2s. } 6\tfrac{4}{5}\text{d.} \times 0.03 = \textbf{£0 15s. } 9\tfrac{1}{4}\textbf{d. per acre.}$$

With regard to the second class of plantations mentioned above —namely, those which have been thinned, but are under full-timber size:—

When trees require to be thinned for the first time, they will then afford certain evidences on which to found calculations of their ultimate produce and value. Therefore, at the time when young trees show evidence of their future health, and until they have attained a full-timber size, the valuation of such plantations should be made with regard to their **Prospective Value.** The number of years the trees will require to arrive at maturity should be assessed; then a calculation should be made of the clear value of all thinnings that are likely to take place before the plantation arrives at maturity; and thirdly, an estimate should be made of the probable value of the mature crop. The total amount of these sums must then be discounted at compound interest for the period the trees require to attain maturity, and the result will exhibit the present transfer-value of the plantation. Although this may be said to be the general rule for valuing plantations of the class under notice, still, in practice, it very frequently requires to be modified in order to adapt it to the particular circumstances of each given case. The correctness of the valuation depends to a very great extent on the skill, judgment, and experience of the valuator.

Throughout the great forest countries of Europe specific instructions are issued by Governments relative to the methods to be adopted with regard to valuations of State property, or of private lands that may have to be expropriated or exchanged for other land.

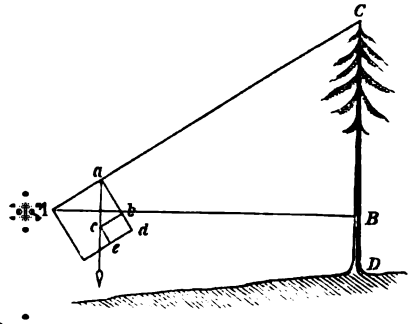
With regard to the third class of plantations as above stated—viz., those which have arrived at full-timber size—every forester ought, in the author's opinion, to be able to value such wood at sight. Few foresters are, he has found, ever called upon to value the two first-named classes of plantations; but the case is altogether different with regard to full-grown trees. Foresters are almost every day called upon to cut down and value trees of full-grown dimensions. In this case it is not the transfer-value of the unripe crop as found upon the land that has to be dealt with: it is the simple value of the wood itself,—the value of each tree as produced by the given soil and situation, according to the treatment of the crop.

Mensuration of Timber Crops.—It is often necessary that full-grown timber trees should be valued previous to their being cut down; and, particularly in the case of a transfer of property, it is absolutely necessary to have this done, seeing that the trees are a part of the property to be sold. In taking the value of timber in its

[illegible] in practice among wood-valuators. [illegible] of each tree by means of a [illegible] measuring the height, and by actually [illegible] a cord, so as to find the contents [illegible] round timber; the other method is [illegible] judging by the eye the number of [illegible]

[illegible] ent has been strongly commended in [illegible] ience, on a much larger scale than is [illegible] d that it is not a reliable method of [illegible] only justifiable when other means are [illegible] rustworthy small instruments as are [illegible] carried in the pocket, actual measure- [illegible] case. As Kohli has shown in his

Fig. 343.



[illegible] ing-Board.

[illegible] ular Timber-Mensuration (*Allgemeine* [illegible] pp. 66, 174, 194), in order to attain [illegible] must practise his eye not merely on [illegible] ds; and he must have considerable [illegible] business if he becomes a trustworthy [illegible] ssing at the contents of a tree can be [illegible] in this respect, unless the apprentice [illegible] he results of his estimate as soon as [illegible] faculty becomes impaired unless the [illegible]

[illegible] or Measuring Height.—All of these [illegible] similarity of the proportion of equal- [illegible] angles is a right angle.

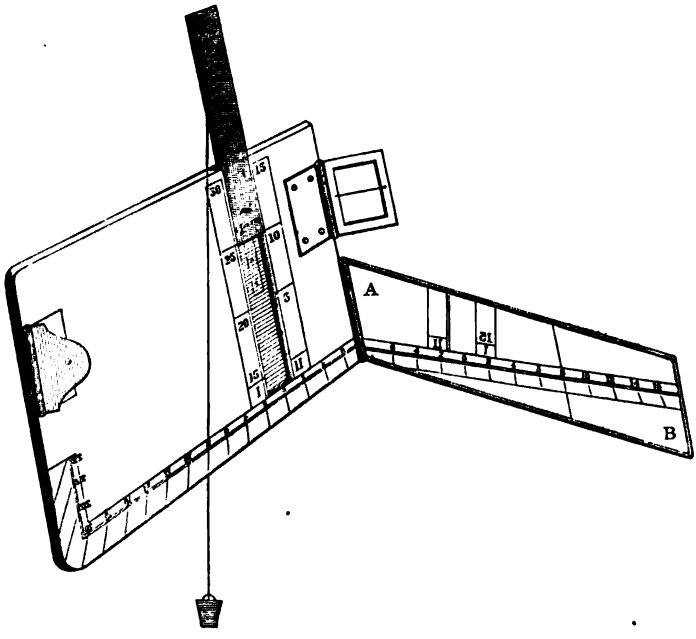
[illegible] Board. In Germany it is called the [illegible] but, curiously enough, at the Forestry [illegible] as awarded by the committee to an [illegible] ment as a new invention. Its form,

and the system upon which it is worked, are shown in Figs. 342 and 343. The board is fixed by a screw sideways upon an upright staff, so as to hold it in true position whilst the readings are being taken. When the board is adjusted so that the top line A*a* fixes the top of the tree C, then, in the similar triangles ABC and *abc*—

$$ab : AB = bc : BC.$$

Say, for example, that AB, the distance from the tree to the eye of the operator, is measured and found to be 70 ft., and that *bc* on the board registers itself as 45, then whatever proportion *ab* bears to AB, *cb* must bear to CB; and if *ab* has been set at 70 ft., it would consequently follow that CB would be 45 ft. in height. To this would, on level ground, have to

Fig. 344.



Faustmann's Mirror Hypsometer.

be added the height of the lower part of the stem BD, which would be the height up to the eye of the operator.

If measurements have to be made on hillsides, then a double reading may often be necessary; and the supplementary reading will have to be added to, or subtracted from, the original observation, according to the position of the operator with reference to the stem.

Faustmann's Mirror Hypsometer (see Fig. 344) is merely another form of applying the same geometrical principle. The light wooden instrument folds up into a paper case about 7 in. long, 4 in. broad, and half an inch thick, so that it is even more easily carried about than the measuring-board. The base of the triangle is fixed by means of a movable arm, that has to be set according to the distance between the tree and the operator. When this is short (0–15 yards, for example), the end marked II. on this

adjustable arm is used in forming the similar triangle; but in long distances (15–30 yards, for example, or in short distances where greater accuracy is desired by means of doubling the distance) the end marked I. is set against the figure representing the number of feet or yards from the stem. Thus, in the illustration, the hypsometer is set at 25 yards; and the reading shows the height of the tree to be 8 yards or 24 ft. In this instrument the adjustment takes place by observation through an aperture at one end and a hair-line at the other, which are brought into position in a right line so as to cut the top of the tree.

This small and handy instrument can also be used for laying out drainage lines, rough road alignments, &c. It costs about 5s. in Germany, where it is very extensively used by valuators.

Weise's Hypsometer likewise rests on the same principle. It consists of a small telescope-tube, through which the observation is taken, after once the distance of the tree has been measured and the upright rod has been adjusted. When the observation is being made and the leaded perpendicular has become steady and true, it is allowed to fall lightly into a toothed scale on the right-hand side, by turning the telescope gently to the left, *i.e.*, off the perpendicular. Hence it registers the height directly, which simply requires to be read off. It is even a handier instrument than Faustmann's, although, being all constructed of brass, it costs somewhat more.

Mackenzie's Dendrometer exhibits another form of applying the same principle. A full description of this instrument, with illustrations, will be found in the *Trans. Scot. Arbor. Socy.* for 1884, vol. x. Part iii. pp. 141, 142.

Girth Measurement may take place either with a tape-line or by means of callipers and of measuring-rods furnished with arms. The latter may be marked so as to read off either the girth or the diameter.

The use of large iron callipers is distinctly more correct than either of the other methods. In girthing the stems with a tape-line, there is a considerable chance of the tape not being placed completely level round the stem; whilst at the same time even the best tape stretches with use, and does not give true readings. Again, in the measuring-rods with arms, the right-hand or loose movable arm is always apt to "play" to a certain extent, which directly affects the correctness of the reading. The use of good large iron callipers is therefore most to be recommended. But, in order that reliable data may be obtained, it is essential that two diameters be taken at right angles to each other, and the mean of these accepted as the correct reading (in girth or diameter according to the scale adopted). No matter what the shape of the stem may be, two readings at right angles are usually more likely to yield true results than any single measurement.

An Estimate of Growing Crops by means of Tables of Average Yield is, as has previously been indicated in referring to the total increment, a method that is reliable as well as convenient, wherever proper data are available from past experience and careful tabulation of actual returns in timber from the various classes of soil and situation, and for the different kinds of forest-trees. But, although applicable for calculations *per acre*, they cannot, as merely average statistics, be expected to give any reliable indication of the actual cubic contents of individual stems, unless the latter should happen to be the average class of stem throughout the crop.

Estimate of the Cubic Contents of Growing Crops of Timber by means of Form-Factors.—The use of form-factors for individual trees only

is open to the same objection as in the case of average yield tables; for they give very reliable general results for masses of timber, but they can only be true for the average stem as regards individual trees. In the preparation of form-factor tables, great care is requisite in selecting the proper type of trees included in each of the separate classes, as otherwise the results cannot possibly be correct.

The **form-factor** is the proportion that exists between the actual quantity of timber contained in a tree and the contents of the ideal cylinder that would be represented by the height of the tree multiplied by the stem section or basal area at $4\frac{1}{3}$ ft. from the ground.

Thus if c = the actual cubic contents of the tree,
and C = the ideal cylinder (= 1.00) formed by the height multiplied into the stem-section at breast-height,
then $c = C \times f$, where f is the reducing factor or **form-factor**,

$$\text{consequently } f = \frac{c}{C}.$$

To illustrate this by an example, say the stem of an Oak is 8 ft. in girth at breast-height, and that the length of the bole is 30 ft.; then the sectional area would be, by the British manner of calculating $(\frac{1}{4}\text{ girth})^2$, 4 ft.; and the cubic contents of the ideal cylinder would be $30 \times 4 = 120$ cubic ft. But if the true contents of the tree were only 66 cubic ft., then the **form-factor** in this case would be—

$$f = \frac{66}{120} = 0.55.$$

The use of **form-factors** plays a great part in timber measurements on the Continent. Of course, the form-factors vary for one and the same kind of tree, according to the nature of the soil and situation, the density of the leaf-canopy, and the age of the crop.

They have been calculated by Burckhardt (*op. cit.*, pp. 158–162) from many thousands of stems, and arranged as given below. But the editor must point out that as the ideal cylinder (= 1.00) is calculated for the true-stem section, and not for the square of the quarter-girth, these form-factors must vary from similar data carefully worked out with special reference to Britain.

In the **Form-factors for the Oak**, four classes of factors were found necessary for the Hanoverian forests; and these may be detailed for the guidance of British foresters:—

I. Refers to indifferent classes of forest on inferior soil; to poor standards in copse; to plantations of inferior development; and to very long-stemmed trees of medium age.

II. Refers to middle-aged trees of moderate height; to mature high-forest trees with good long stems; to Oaks growing in copse or in open plantations, on soils of moderate quality.

III. Refers to mature high-forest of a somewhat open description with a good length of stem; to high-forest crops that have been stimulated to enhanced increment by the method of partial clearance; to old Oak standards that have kept over for a second generation along with a crop of Beech; to Oak standards in copse formed on good soil; and to very wide plantations on good land.

IV. Refers to Oaks that have grown in the open, which have very broad, full crowns and short stems,—*e.g.*, Oaks on grazing-land and in parks.

FORM-FACTORS FOR THE OAK (exclusive of branch-wood below 2 in. in diameter).

Diameter at breast-height.	Class of Form-factor.			
	I.	II.	III.	IV.
Inches.				
4	0.45 to 0.47			
6	0.46 " 0.48			
8	0.47 " 0.50			
10	0.47	0.50	0.52	
12	0.48	0.51	0.54	
15	0.49	0.52	0.55	0.58
18	0.50	0.53	0.565	0.60
21	0.51	0.54	0.58	0.62
24	0.52	0.555	0.59	0.63
27	0.53	0.565	0.60	0.64
30	0.54	0 58	0.615	0.65
36	0.55	0.60	0.63	0.66
45	...	0.61	0.64	0.67

The form-factors for the Oak are subject to great variations, especially in old trees with large coronal development. *Including the brushwood* they may be said to be

For Class I. about 0.55 on the average
" II. " 0.60 " "
" III. " 0.65 " "
" IV. from 0.70 to 0.72 " (but ranging from 0.52 to 0.80).

Standard Oaks growing in copse have a form-factor of about 0.67 on the average.

"The actual quantity of timber contained in very large, healthy Oaks having broad, full crowns, and a moderate height (seldom attaining 100 ft.), may usually be reckoned, inclusive of branch-wood, at two-thirds of the total height of the tree for the ideal cylinder to be multiplied by the form-factor 0·7 (*idem*, p. 159)."

In the **Form-factors for the Beech** three classes of factors are distinguished—

I. For middle-aged to mature crops growing in normal density of close canopy; for crowded woods where the height is good, but the girth small; for mature, or nearly mature, wood on inferior classes of soil; for crops in which there is a number of trees raised from stool-shoots; for old gnarled trees, and those that are slightly stag-headed; and for standards in copse. This class of form-factor applies also to Hornbeam growing in high-forest.

II. For mature, or nearly mature, crops of high-forest of fair normal density, and of moderate to good height; also for the inferior class of standards during natural regeneration of the crops.

III. For large, tall, full-wooded stems; for old plantations; for the more vigorous class of forest standards during natural regeneration; and for old standard trees treated by the method of partial clearance.

FORM-FACTORS FOR THE BEECH, exclusive of branch-wood under 2 in. in diameter.

Diameter at breast-height.	Class of Form-factor.		
	I.	II.	III.
Inches.			
4		0.43 to 0.45	
6		0.445 " 0.465	
8	0.45	0.48	
10	0.46	0.485	0.495
12	0.47	0.49	0.51
15	0.48	0.505	0.525
18	0.49	0.52	0.545
21	0.50	0.53	0.555
27	0.52	0.55	0.57

Including the small branch-wood the form-factor usually ranges—

In High-Forest—

In Class I. between 0.54 for heights of 50 ft., and 0.51 for heights of 100 ft.
" II. " 0.59 " " 0.57 " "
" III. " 0.64 " " 0.62 " "

In Copse—

From 0.60 to 0.63 with very energetic growth.
" 0.57 " 0.60 under average circumstances.
" 0.54 " 0.57 on inferior soil and situation.
} It rises with the girth, and is but little influenced by the height.

In the **Form-factors for the Spruce** two classes have been formed, viz.:—

I. For branching stems grown with a comparatively large individual growing-space; for stems that have rather a conical shape, owing to red-rot, or for any other reason; and for crops growing on an inferior soil or situation.

II. For normal crops of Spruce.

FORM-FACTORS FOR SPRUCE, including the Top-end.

Diameter at breast-height.	Class of Form-factor.	
	I.	II.
Inches.		
4	0.53	0.55
6	0.50	0.525
8	0.48	0.505
10	0.465	0.485
12	0.45	0.475
15	0.435	0.46
18	0.42	0.445
21	0.40	0.425
24	0.385	0.41
27	0.37	0.395
30	0.355	0.38

In the **Form-factors for the Scots Pine** two classes have also been formed, viz. :—

I. Includes the top-ends, or represents the actual quantity of timber down to about 3 in. (full measurement) in diameter in mature crops, or those approaching maturity.

II. Includes all timber down to 2 in. in diameter.

FORM-FACTORS FOR SCOTS PINE.

Height of Stem.	Class of Form-factor.	
	I.	II.
Feet.		
30	0.49 to 0.51	
40	0.475	0.495
50	0.46	0.48
60	0.45	0.47
70	0.445	0.46
80	0.44	0.455
90	0.435	0.445
100	0.425	0.435

When the form-factor is intended to include the smaller branch-wood, it varies as under :—

For trees from 40 to 60 ft. in height, from 0.53 to 0.50
" " 60 " 80 " " 0.50 " 0 47
" " 80 " 100 " " 0.47 " 0.45

"When the stems are very large in girth in comparison with their height, the form-factor becomes diminished as regards both the contents of the stem alone and the total quantity of timber; hence very thick stems of Scots Pine of very varying heights differ but little with regard to the form-factor, as has been proved from a very large number of averages. This extreme proportion between girth and height affects the form-factor to such a degree that, in the case of *long* thick stems, the latter may be even greater than for *short* thick stems. Hence the following form-factors are applicable (*idem*, p. 161) :—

Diameter.	Stems of 50 ft. in height. Form-factor for		Stems of 90 ft. in height. Form-factor for	
	The stem alone.	Total cubic contents.	The stem alone.	Total cubic contents.
Inches.				
22	0.420	0.450	0.425	0.440
18	0.440	0.470	0.425	0.445
For smaller sizes	0.460	0.480	0.435	0.445

"Leaving out of consideration the top-ends up to about 4 in. in diameter, the following form-factors may be taken :—

For tree-crops of average height . = 0.44
For very long-stemmed crops . = 0.42
For very branching and rough stems = 0.38

"For poles, that have been trimmed by lopping the branches, but whose top-ends are still retained, the following form-factors are applicable :—

Length of pole, 30 ft. = 0.51
" " 40 " = 0.48
" " 50 " = 0.46"

In the Bavarian *Massentafeln*, or Average Tables of Yield, the following are given as the Form-factors for the Silver Fir and the Larch, including the whole stem to the top-end :—

FORM-FACTORS FOR THE SILVER FIR.

Diameter.	Crops approaching maturity.		Mature crops.	
	Height of crop.	Form-factor.	Height of crop.	Form-factor.
Inches.	Feet.		Feet.	
6	30–70	0.546	30–50	0.574
12	40–110	0.508	40–90	0.534
18	70–120	0.467	50–110	0.500
24	...	...	70–150	0.465
30	...	...	90–150	0.438

FORM-FACTORS FOR MATURE CROPS OF LARCH.

Diameter.	Height of crop.	Form-factor.
Inches.	Feet.	
6	30–60	0.509
12	50–110	0.445
18	70–130	0.387
24	80–130	0.328

The Form-factors for the Birch range from 0·39 to 0·42 for the quantity of timber contained in the stem and crown, exclusive of branchwood below 2 in. in diameter; whilst for the total cubic contents, including the smaller branches, the factors vary from about 0·47 to 0·51. The form-factor increases with the girth; but it diminishes again with either very short or unusually long stems, in which cases it sinks to about 0·37 for timber only, and about 0·45 for the total cubic contents.

The Form-factors for the Alder are practically the same as those previously given under Classes I. and II. for the Beech.

Where large woodlands are being operated with, the use of Average Yield Tables is, on the whole, most advisable. Thus the application of the Bavarian *Massentafeln*, even in different parts of Germany, yielded results that are incomparably superior to any that could be obtained by ocular

estimate. According to G. Heyer (*Waldertrags-Regelung*, 1883, p. 147), the following differences were noticeable on the crops being actually felled and worked up on experimental areas:—

Locality.	No. of stems measured.	Percentage of	
		Excess.	Deficit.
		Shown by the average yield tables.	
Rüdersdorf forest	263	...	0.6
Throughout Northern Prussia .	70,546	1.8	...
Würtemberg	1,340	0.003	...
Hesse	8,401	0.9	...

Next to the use of Average Yield Tables in point of convenience, and with respect to correctness, comes the method of selecting average sample areas, either through making actual measurements of the quantity of timber growing on these, or else by calculating out the average stem, and then either felling and measuring its actual contents, or else estimating them by means of the form-factor.

As height, girth, and cubic contents are all different expressions of the vital energy of the trees, they are all, in properly managed woodland crops, more or less distinctly proportional to each other. The most convenient manner of ascertaining the true average class of stem will therefore be by means of the average diameter, or girth, or basal area of the stem; for that *tree* will be of *average size* whose section at breast-height is the average of the basal areas of all the trees forming the sample-plot. Hence all the trees throughout the sample-plot should be measured at breast-height, and registered in the field-book in columns varying by half an inch or 1 in. for diameter (or say 1 in. to 3 in. for girth).

When this has been done, and the total basal area has been calculated by means of the ordinary superficial tables found in mensuration-books, then the section or basal area of the true average stem is found by dividing the total sectional area by the number of stems. Having thus determined the average stem, specimens of it should be looked for, and either felled and measured accurately, or else calculated by the aid of a form-factor after the height has been measured with a hypsometer. Thus, supposing the girth to be 4 ft., then the square of the quarter girth would be 1 ft.; and if the height of the sample specimens or true average stems were found to be 60 ft. on the average, and the form-factor were accessible at 0·5, then the actual cubic contents would be—

$$1 \text{ sq. ft.} \times 60 \text{ ft.} \times 0{\cdot}5 = \mathbf{30 \text{ cubic ft.}}$$

Consequently the total contents of the growing crop would consist of the total number of stems per acre multiplied by 30 cubic ft.

As reliable form-factor tables do not yet exist for Scotland or England, it will at present be found best to fell a few sample stems,—or even one, if that be alone permissible,—and to calculate the cubic contents of the bole by means of stem sections, or less accurately by means of the total length of the stem multiplied by its section at half its length. This will not, however, include the branch-wood, as in the case of average yield tables and form-factor tables. For convenience, the following table of cubic ft. and decimals of 1 cubic ft. may be given for ready reference in such calculations:—

CUBIC CONTENTS OF ROUND LOGS = $\left(\frac{\text{Girth}}{4}\right)^2$, in Cubic Feet and Decimals of 1 Cubic Foot.

Length in feet.	Mean Girth in Feet and Inches.											
	3′	3′-1″	3′-2″	3′-3″	3′-4″	3′-5″	3′-6″	3′-7″	3′-8″	3′-9″	3′-10″	3′-11″
10	5.6	5.9	6.3	6.6	6.9	7.3	7.7	8.0	8.4	8.8	9.2	9.6
11	6.2	6.5	6.9	7.3	7.6	8.0	8.4	8.8	9.2	9.7	10.1	10.5
12	6.8	7.1	7.5	7.9	8.3	8.8	9.2	9.6	10.1	10.5	11.0	11.5
13	7.3	7.7	8.1	8.6	9.0	9.5	10.0	10.4	10.9	11.4	11.9	12.5
14	7.9	8.3	8.8	9.2	9.7	10.2	10.7	11.2	11.8	12.3	12.9	13.4
15	8.4	8.9	9.4	9.9	10.4	10.9	11.5	12.0	12.6	13.2	13.8	14.4
16	9.0	9.5	10.0	10.6	11.1	11.7	12.2	12.8	13.4	14.1	14.7	15.3
17	9.6	10.1	10.7	11.2	11.8	12.4	13.0	13.6	14.3	14.9	15.6	16.3
18	10.1	10.7	11.3	11.9	12.5	13.1	13.8	14.4	15.1	15.8	16.5	17.3
19	10.7	11.3	11.9	12.5	13.2	13.9	14.5	15.2	16.0	16.7	17.4	18.2
20	11.3	11.9	12.5	13.2	13.9	14.6	15.3	16.1	16.8	17.6	18.4	19.2
21	11.8	12.5	13.2	13.8	14.6	15.3	16.1	16.9	17.6	18.5	19.3	20.1
22	12.4	13.1	13.8	14.5	15.3	16.1	16.8	17.7	18.5	19.3	20.2	21.1
23	12.9	13.7	14.4	15.2	16.0	16.8	17.6	18.5	19.3	20.2	21.1	22.1
24	13.5	14.3	15.0	15.8	16.7	17.5	18.4	19.3	20.2	21.1	22.0	23.0
25	14.1	14.9	15.7	16.5	17.4	18.2	19.1	20.1	21.0	22.0	23.0	24.0
26	14.6	15.4	16.3	17.2	18.1	19.1	19.9	20.9	21.8	22.9	23.9	24.9
27	15.2	16.0	16.9	17.8	18.7	19.7	20.7	21.7	22.7	23.7	24.8	25.9
28	15.8	16.6	17.5	18.5	19.4	20.4	21.4	22.5	23.5	24.6	25.7	26.8
29	16.3	17.2	18.2	19.1	20.1	21.2	22.2	23.3	24.4	25.5	26.6	27.8
30	16.9	17.8	18.8	19.8	20.8	21.9	23.0	24.1	25.2	26.4	27.6	28.8
31	17.4	18.4	19.4	20.5	21.5	22.6	23.7	24.9	26.0	27.2	28.5	29.7
32	18.0	19.0	20.1	21.1	22.2	23.3	24.5	25.7	26.9	28.1	29.4	30.7
33	18.6	19.6	20.7	21.8	22.9	24.1	25.3	26.5	27.7	29.0	30.3	31.6
34	19.1	20.2	21.3	22.4	23.6	24.8	26.0	27.3	28.6	29.9	31.2	32.6
35	19.7	20.8	21.9	23.1	24.3	25.5	26.8	28.1	29.4	30.8	32.1	33.6
36	20.3	21.4	22.6	23.8	25.0	26.3	27.6	28.9	30.2	31.6	33.1	34.5
37	20.8	22.0	23.2	24.4	25.7	27.0	28.3	29.7	31.1	32.5	34.0	35.5
38	21.4	22.6	23.8	25.1	26.4	27.7	29.1	30.5	31.9	33.4	34.9	36.4
39	21.9	23.2	24.4	25.7	27.1	28.5	29.9	31.3	32.8	34.3	35.8	37.4
40	22.5	23.8	25.1	26.4	27.8	29.2	30.6	32.1	33.6	35.2	36.7	38.4

CUBIC CONTENTS OF ROUND LOGS = $\left(\frac{\text{Girth}}{4}\right)^2$, in Cubic Feet and Decimals of 1 Cubic Foot.

Length in feet.	Mean Girth in Feet and Inches.											
	4′	4′-1″	4′-2″	4′-3″	4′-4″	4′-5″	4′-6″	4′-7″	4′-8″	4′-9″	4′-10″	4′-11″
10	10.0	10.4	10.9	11.3	11.7	12.2	12.7	13.1	13.6	14.1	14.6	15.1
11	11.0	11.5	11.9	12.4	12.9	13.4	13.9	14.4	15.0	15.5	16.1	16.6
12	12.0	12.5	13.0	13.5	14.1	14.6	15.2	15.8	16.3	16.9	17.5	18.1
13	13.0	13.5	14.1	14.7	15.3	15.8	16.5	17.1	17.7	18.3	19.0	19.6
14	14.0	14.6	15.2	15.8	16.4	17.1	17.7	18.4	19.1	19.7	20.4	21.2
15	15.0	15.6	16.3	16.9	17.6	18.3	19.0	19.7	20.4	20.2	21.9	22.7
16	16.0	16.7	17.4	18.1	18.8	19.5	20.2	21.0	21.8	22.6	23.4	24.2
17	17.0	17.7	18.4	19.2	20.0	20.7	21.5	22.3	23.1	24.0	24.8	25.7
18	18.0	18.8	19.5	20.3	21.1	21.9	22.8	23.6	24.5	25.4	26.3	27.2
19	19.0	19.8	20.6	21.4	22.3	23.2	24.0	24.9	25.9	26.8	27.7	28.7
20	20.0	20.8	21.7	22.6	23.5	24.4	25.3	26.3	27.2	28.2	29.2	30.2
21	21.0	21.9	22.8	23.7	24.6	25.6	26.6	27.6	28.6	29.6	30.7	31.7
22	22.0	22.9	23.9	24.8	25.8	26.8	27.8	28.9	29.9	31.0	32.1	33.2
23	23.0	24.0	25.0	26.0	27.0	28.0	29.1	30.2	31.3	32.4	33.6	34.7
24	24.0	25.0	26.0	27.1	28.2	29.3	30.4	31.5	32.7	33.8	35.0	36.3
25	25.0	26.1	27.1	28.2	29.3	30.5	31.6	32.8	34.0	35.3	36.5	37.8
26	26.0	27.1	28.2	29.4	30.5	31.7	32.9	34.1	35.4	36.7	38.0	39.3
27	27.0	28.1	29.3	30.5	31.7	32.9	34.2	35.4	36.7	38.1	39.4	40.8
28	28.0	29.2	30.4	31.6	32.9	34.1	35.4	36.8	38.1	39.5	40.9	42.3
29	29.0	30.2	31.5	32.7	34.0	35.4	36.7	38.1	39.5	40.9	42.3	43.8
30	30.0	31.3	32.6	33.9	35.2	36.6	38.0	39.4	40.8	42.3	43.8	45.3
31	31.0	32.3	33.6	35.0	36.4	37.8	39.2	40.7	42.2	43.7	45.3	46.8
32	32.0	33.3	34.7	36.1	37.5	39.0	40.5	42.0	43.6	45.1	46.7	48.3
33	33.0	34.4	35.8	37.3	38.7	40.2	41.8	43.3	44.9	46.5	48.2	49.9
34	34.0	35.4	36.9	38.4	39.9	41.5	43.0	44.6	46.3	47.9	49.6	51.4
35	35.0	36.5	38.0	39.5	41.1	42.7	44.3	46.0	47.6	49.4	51.1	52.9
36	36.0	37.5	39.1	40.6	42.2	43.9	45.6	47.3	49.0	50.8	52.6	54.4
37	37.0	38.6	40.1	41.8	43.4	45.1	46.8	48.6	50.4	52.2	54.0	55.9
38	38.0	39.6	41.2	42.9	44.6	46.3	48.1	49.9	51.7	53.6	55.5	57.4
39	39.0	40.6	42.3	44.0	45.8	47.5	49.4	51.2	53.1	55.0	56.9	58.9
40	40.0	41.7	43.4	45.2	46.9	48.8	50.6	52.5	54.4	56.4	58.4	60.4

CUBIC CONTENTS OF ROUND LOGS = $\left(\frac{\text{Girth}}{4}\right)^2$, in Cubic Feet and Decimals of 1 Cubic Foot.

Length in feet.	MEAN GIRTH IN FEET AND INCHES.											
	5′	5′-1″	5′-2″	5′-3″	5′-4″	5′-5″	5′-6″	5′-7″	5′-8″	5′-9″	5′-10″	5′-11″
10	15.6	16.2	16.7	17.2	17.8	18.3	18.9	19.5	20.1	20.7	21.3	21.9
11	17.2	17.8	18.4	18.9	19.6	20.2	20.8	21.4	22.1	22.7	23.4	24.1
12	18.8	19.4	20.0	20.7	21.3	22.0	22.7	23.4	24.1	24.8	25.5	26.3
13	20.3	21.0	21.7	22.4	23.1	23.8	24.6	25.3	26.1	26.9	27.6	28.4
14	21.9	22.6	23.4	24.1	24.9	25.7	26.5	27.3	28.1	28.9	29.8	30.6
15	23.4	24.2	25.0	25.8	26.7	27.5	28.4	29.2	30.1	31.0	31.9	32.8
16	25.0	23.8	26.7	27.6	28.4	29.3	30.2	31.2	32.1	33.1	34.0	35.0
17	26.6	27.5	28.4	29.3	30.2	31.2	32.1	33.1	34.1	35.1	36.2	37.2
18	28.1	29.1	30.0	31.0	32.0	33.0	34.0	35.1	36.1	37.2	38.3	39.3
19	29.7	30.7	31.7	32.7	33.8	34.8	35.9	37.0	38.1	39.3	40.4	41.6
20	31.3	32.3	33.4	34.5	35.6	36.7	37.8	39.0	40.1	41.3	42.5	43.8
21	32.8	33.9	35.0	36.2	37.3	38.5	39.7	40.9	42.1	43.4	44.7	45.9
22	34.4	35.5	36.7	37.9	39.1	40.3	41.6	42.9	44.2	45.5	46.8	48.1
23	35.9	37.1	38.4	39.6	40.9	42.2	43.5	44.8	46.2	47.5	48.9	50.3
24	37.5	38.8	40.0	41.3	42.7	44.0	45.4	46.8	48.2	49.6	51.0	52.5
25	39.1	40.4	41.7	43.1	44.4	45.8	47.3	48.7	50.2	51.7	53.2	54.7
26	40.6	42.0	43.4	44.8	46.2	47.7	49.2	50.7	52.2	53.7	55.3	56.9
27	42.2	43.6	45.0	46.5	48.0	49.5	51.0	52.6	54.2	55.8	57.4	59.1
28	43.8	45.2	46.7	48.2	49.8	51.3	52.9	54.6	56.2	57.9	59.5	61.3
29	45.3	46.8	48.4	50.0	51.6	53.2	54.8	56.5	58.2	59.9	61.7	63.4
30	46.9	48.5	50.1	51.7	53.3	55.0	56.7	58.5	60.2	62.0	63.8	65.6
31	48.4	50.1	51.7	53.4	55.1	56.8	58.6	60.4	62.2	64.1	65.9	67.8
32	50.0	51.7	53.4	55.1	56.9	58.7	60.5	62.3	64.2	66.1	68.1	70.0
33	51.6	53.3	55.1	56.8	58.7	60.5	62.4	64.3	66.2	68.2	70.2	72.2
34	53.1	54.9	56.7	58.6	60.4	62.3	64.3	66.2	68.2	70.3	72.3	74.4
35	54.7	56.5	58.4	60.3	62.2	64.2	66.2	68.2	70.2	72.3	74.4	76.6
36	56.3	58.1	60.1	62.0	64.0	66.0	68.1	70.1	72.2	74.4	76.6	78.8
37	57.8	59.8	61.7	63.7	65.8	67.8	70.0	72.1	74.3	76.5	78.7	81.0
38	59.4	61.4	63.4	65.5	67.6	69.7	71.8	74.0	76.3	78.5	80.8	83.1
39	60.9	63.0	65.1	67.2	69.3	71.5	73.7	76.0	78.3	80.6	82.9	85.3
40	62.5	64.6	66.7	68.9	71.1	73.4	75.6	77.9	80.3	82.7	85.1	87.5

CUBIC CONTENTS OF ROUND LOGS = $\left(\frac{\text{Girth}}{4}\right)^2$, in Cubic Feet and Decimals of 1 Cubic Foot.

Length in feet.	Mean Girth in Feet and Inches.											
	6′	6′–1″	6′–2″	6′–3″	6′–4″	6′–5″	6′–6″	6′–7″	6′–8″	6′–9″	6′–10″	6′–11″
10	22.5	23.1	23.8	24.4	25.1	25.7	26.4	27.1	27.8	28.5	29.2	29.9
11	24.8	25.4	26.1	26.9	27.6	28.3	29.0	29.8	30.6	31.3	32.1	32.9
12	27.0	27.8	28.5	29.3	30.1	30.9	31.7	32.5	33.3	34.2	35.0	35.9
13	29.3	30.1	30.9	31.7	32.6	33.5	34.3	35.2	36.1	37.0	37.9	38.9
14	31.5	32.4	33.3	34.2	35.1	36.0	37.0	37.9	38.9	39.9	40.9	41.9
15	33.8	34.7	35.7	36.6	37.6	38.6	39.6	40.6	41.7	42.7	43.8	44.9
16	36.0	37.0	38.0	39.1	40.1	41.2	42.2	43.3	44.4	45.6	46.7	47.8
17	38.3	39.3	40.4	41.5	42.6	43.7	44.9	46.0	47.2	48.4	49.6	50.8
18	40.5	41.6	42.8	43.9	45.1	46.3	47.5	48.8	50.0	51.3	52.5	53.8
19	42.8	43.9	45.2	46.4	47.6	48.9	50.2	51.5	52.8	54.1	55.4	56.8
20	45.0	46.3	47.5	48.8	50.1	51.5	52.8	54.2	55.6	57.0	58.4	59.8
21	47.3	48.6	49.9	51.3	52.6	54.0	55.5	56.9	58.3	59.8	61.3	62.8
22	49.5	50.9	52.3	53.7	55.2	56.6	58.1	59.6	61.1	62.6	64.2	65.8
23	51.8	53.2	54.7	56.2	57.7	59.2	60.7	62.3	63.9	65.5	67.1	68.8
24	54.0	55.5	57.0	58.6	60.2	61.8	63.4	65.0	66.7	68.3	70.0	71.8
25	56.3	57.8	59.4	61.0	62.7	64.3	66.0	67.7	69.4	71.2	73.0	74.8
26	58.5	60.1	61.8	63.5	65.2	66.9	68.7	70.4	72.2	74.0	75.9	77.7
27	60.8	62.4	64.2	65.9	67.7	69.5	71.3	73.1	75.0	76.9	78.8	80.7
28	63.0	64.8	66.5	68.4	70.2	72.1	73.9	75.8	77.8	79.7	81.7	83.7
29	65.3	67.1	68.9	70.8	72.7	74.6	76.6	78.6	80.6	82.6	84.6	86.7
30	67.5	69.4	71.3	73.2	75.2	77.2	79.2	81.3	83.3	85.4	87.6	89.7
31	69.8	71.7	73.7	75.7	77.7	79.8	81.9	84.0	86.1	88.3	90.5	92.7
32	72.0	74.0	76.1	78.1	80.2	82.3	84.5	86.7	88.9	91.1	93.4	95.7
33	74.3	76.3	78.4	80.6	82.7	84.9	87.1	89.4	91.7	94.0	96.3	98.7
34	76.5	78.6	80.8	83.0	85.2	87.5	89.8	92.1	94.4	96.8	99.2	101.7
35	78.8	81.0	83.2	85.4	87.7	90.1	92.4	94.8	97.2	99.7	102.1	104.7
36	81.0	83.3	85.6	87.9	90.2	92.6	95.1	97.5	100.0	102.5	105.1	107.6
37	83.3	85.6	87.9	90.3	92.8	95.2	97.7	100.2	102.8	105.4	108.0	110.6
38	85.5	87.9	90.3	92.8	95.3	97.8	100.3	102.9	105.6	108.2	110.9	113.6
39	87.8	90.2	92.7	95.2	97.8	100.4	103.0	105.6	108.3	111.1	113.8	116.6
40	90.0	92.5	95.1	97.7	100.3	102.9	105.6	108.4	111.1	113.9	116.7	119.6

CUBIC CONTENTS OF ROUND LOGS = $\left(\frac{\text{Girth}}{4}\right)^2$, in Cubic Feet and Decimals of 1 Cubic Foot.

Length in feet.	Mean Girth in Feet and Inches.											
	7′	7′-1″	7′-"2	7′-3″	7′-4″	7′-5″	7′-6″	7′-7″	7′-8″	7′-9″	7′-10″	7′-11″
10	30.6	31.4	32.1	32.9	33.6	34.4	35.2	35.9	36.7	37.5	38.4	39.2
11	33.7	34.5	35.3	36.1	37.0	37.8	38.7	39.5	40.4	41.3	42.2	43.1
12	36.8	37.6	38.5	39.4	40.3	41.3	42.2	43.1	44.1	45.0	46.0	47.0
13	39.8	40.8	41.7	42.7	43.7	44.7	45.7	46.7	47.8	48.8	49.9	50.9
14	42.9	43.9	44.9	46.0	47.1	48.1	49.2	50.3	51.4	52.6	53.7	54.8
15	45.9	47.0	48.2	49.3	50.4	51.6	52.7	53.9	55.1	56.3	57.5	58.8
16	49.0	50.2	51.4	52.6	53.8	55.0	56.2	57.5	58.8	60.1	61.4	62.7
17	52.1	53.3	54.6	55.8	57.1	58 4	59.8	61.1	62.5	63.8	65.2	66.6
18	55.1	56.4	57.8	59.1	60.5	61.9	63.3	64.7	66.1	67.6	69.0	70.5
19	58.2	59.6	61.0	62.4	63.9	65.3	66.8	68.3	69.8	71 3	72.9	74.4
20	61.3	62.7	64.2	65.7	67.2	68.8	70.3	71.9	73.5	75.1	76.7	78.3
21	64.3	65.9	67.4	69.0	70.6	72.2	73.8	75.5	77.1	78.8	80.5	82.3
22	67.4	69.0	70.6	72.3	73.9	75.6	77.3	79.1	80.8	82.6	84.4	86.2
23	70.4	72.1	73.8	75.6	77.3	79.1	80.9	82.7	84.5	86.3	88.2	90.1
24	73.5	75.3	77.0	78.8	80.7	82.5	84.4	86.3	88.2	90.1	92.0	94.0
25	76.6	78.4	80.3	82.1	83.0	85.9	87.9	89.9	91.8	93.8	95.9	97.9
26	79.6	81.5	83.5	85.5	87.4	89.4	91.4	93.4	95.5	97.6	99.7	101.8
27	82.7	84.7	86.7	88.7	90.7	92.8	94.9	97.0	99.2	101.4	103.5	105.8
28	85.8	87.8	89.9	92.0	94.1	96.3	98.4	100.6	102.9	105.1	107.4	109.7
29	88.8	90.9	93.1	95.3	97.5	99.7	102.0	104.2	106.5	108.9	111.2	113.6
30	91.9	94.1	96.3	98.6	100.8	103.1	105.5	107.8	110.2	112.6	115.1	117.5
31	94.9	97.2	99.5	101.8	104.2	106.6	109.0	111.4	113.9	116.4	118.9	121.4
32	98.0	100.3	102.7	105.1	107.6	110.0	112.5	115.0	117.6	120.1	122.7	125.3
33	101.1	103.5	105.9	108.4	110.9	113.5	116.0	118.6	121.2	123.9	126.6	129.3
34	104.1	106.6	109.1	111.7	114.3	116.9	119.5	122.2	124.9	127.6	130.4	133.2
35	107.2	109.8	112.4	115.0	117.6	120.3	123.0	125.8	128.6	131.4	134.2	137.1
36	110.3	112.9	115.6	118.3	121.0	123.8	126.6	129.4	132.2	135.1	138.1	141.0
37	113.3	116.0	118.8	121.6	124.4	127.2	130.1	133.0	135.9	138.9	141.9	144.9
38	116.4	119.2	122.0	124.8	127.7	130.6	133.6	136.6	139.6	142.6	145.7	148.8
39	119.4	122.3	125.2	128.1	131.1	134.1	137.1	140.2	143.3	146.4	149.6	152.8
40	122.5	125.4	128.4	131.4	134.4	137.5	140.6	143.8	146.9	150.2	153.4	156.7

CUBIC CONTENTS OF ROUND LOGS = $\left(\frac{\text{Girth}}{4}\right)^2$, in Cubic Feet and Decimals of 1 Cubic Foot.

Length in feet.	MEAN GIRTH IN FEET AND INCHES.											
	8′	8′–1″	8′–2″	8′–3″	8′–4″	8′–5″	8′–6″	8′–7″	8′–8″	8′–9″	8′–10″	8′–11″
10	40.0	40.8	41.7	42.5	43.4	44.3	45.2	46.0	46.9	47.9	48.8	49.7
11	44.0	44.9	45.9	46.8	47.7	48.7	49.7	50.7	51.6	52.6	53.6	54.7
12	48.0	49.0	50.0	51.0	52.1	53.1	54.2	55.3	56.3	57.4	58.5	59.6
13	52.0	53.1	54.2	55.3	56.4	57.6	58.7	59.9	60.0	62.2	63.4	64.6
14	56.0	57.2	58.4	59.6	60.8	62.0	63.2	64.5	65.7	67.0	68.3	69.6
15	60.0	60.3	62.5	63.8	65.1	66.4	67.7	69.1	70.4	71.8	73.2	74.5
16	64.0	65.3	66.7	68.1	69.4	70.8	72.2	73.7	75.1	76.6	78.0	79.5
17	68.0	69.4	70.9	72.3	73.8	75.3	76.8	78.3	79.8	81.3	82.9	84.5
18	72.0	73.5	75.0	76.6	78.1	79.7	81.3	82.9	84.5	86.1	87.8	89.4
19	76.0	77.6	79.2	80.8	82.5	84.1	85.8	87.5	89.2	90.9	92.6	94.4
20	80.0	81.7	83.4	85.1	86.8	88.6	90 3	92.1	93.9	95.7	97.5	99.4
21	84.0	85.8	87.5	89.3	91.1	93.0	94.8	96.7	98.6	100.5	102.4	104.4
22	88.0	89.8	91.7	93.6	95.5	97.4	99.3	101.3	103.3	105.3	107.3	109.3
23	92.0	93.9	95.9	97.8	99.8	101.8	103.9	105.9	108.0	110.1	112.2	114.3
24	96.0	98.0	100.0	102.1	104.2	106.3	108.4	110.5	112.7	114.8	117.0	119.3
25	100.0	102.1	104.2	106.3	108.5	110.7	112.9	115.1	117.4	119.6	121.9	124.2
26	104.0	106.2	108.4	110.6	112.8	115.1	117.4	119.7	122.1	124.4	126.8	129.2
27	108.0	110.3	112.5	114.9	117.2	119.5	121.9	124.3	126.7	129.2	131.7	134.2
28	112.0	114.3	116.7	119.1	121.5	124.0	126.4	128.9	131.4	134.0	136 5	139.1
29	116.0	117.4	120.9	123.4	125.9	128.4	131.0	133.5	136.1	138.8	141.4	144.1
30	120.0	122.5	125.1	127.6	130.2	132.8	135.5	138.1	140.8	143.6	146.3	149.1
31	124.0	126.6	129.2	131.9	134.5	137.3	140.0	142.7	145.5	148.3	151.2	154.0
32	128.0	130.7	133.4	136.1	138.9	141.7	144.5	147.3	150.2	153.1	156.1	159.0
33	132.0	134.8	137.6	140.4	143.2	146.1	149.0	152.0	154.9	157.9	160.9	164.0
34	136.0	138.8	141.7	144.6	147.6	150.5	153.5	156.6	159.6	162.7	165.8	169.0
35	140.0	142.9	145.9	148.9	151.9	155.0	158.8	161.2	164.3	167.5	170.7	173.9
36	144.0	147.0	150.1	153.1	156.2	159.4	162.6	165.8	169.0	172.3	175.6	178.9
37	148.0	151.1	154.2	157.4	160.6	163.8	167.1	170.4	173.7	177.1	180.4	183.9
38	152.0	155.2	158.4	161.6	164.9	168.2	171.6	175.0	178.4	181.8	185.3	188.8
39	156.0	159.3	162.6	165.9	169.3	172.7	176.1	179.6	183.1	186.6	190.2	193.8
40	160.0	163.4	166.7	170.2	173.6	177.1	180.6	184.2	187.8	191.4	195.1	198.8

CUBIC CONTENTS OF ROUND LOGS = $\left(\frac{\text{Girth}}{4}\right)^2$, in Cubic Feet and Decimals of 1 Cubic Foot.

Length in feet.	MEAN GIRTH IN FEET AND INCHES.											
	9′	9′–1″	9′–2″	9′–3″	9′–4″	9′–5″	9′–6″	9′–7″	9′–8″	9′–9″	9′–10″	9′–11″
10	50.6	51.6	52.5	53.5	54.4	55.4	56.4	57.4	58.4	59.4	60.4	61.5
11	55.7	56.7	57.8	58.8	59.9	61.0	62.0	63.1	64.2	65.4	66.5	67.6
12	60.8	61.9	63.0	64.2	65.3	66.5	67.7	68.9	70.1	71.3	72.5	73.8
13	65.8	67.0	68.3	69.5	70.8	72.0	73.3	74.6	75.9	77.2	78.6	79.9
14	70.9	72.2	73.5	74.9	76.2	77.6	79.0	80.4	81.8	83.2	84.6	86.0
15	75.9	77.4	78.8	80.2	81.7	83.1	84.6	86.1	87.6	89.1	90.7	92.2
16	81.0	82.5	84.0	85.6	87.1	88.7	90.2	91.8	93.4	95.1	96.7	98.3
17	86.1	87.7	89.3	90.9	92.6	94.2	95.9	97.6	99.3	101.0	102.7	104.5
18	91.1	92.8	94.5	96.3	98.0	99.8	101.5	103.3	105.1	106.9	108.8	110.6
19	96.2	98.0	99.8	101.6	103.4	105.3	107.2	109.1	111.0	112.9	114.8	116.8
20	101.3	103.1	105.0	107.0	108.9	110.8	112.8	114.8	116.8	118.8	120.9	122.9
21	106.3	108.3	110.3	112.3	114.3	116.4	118.5	120.5	122.6	124.8	126.9	129.1
22	111.4	113.4	115.5	117.6	119.8	121.9	124.1	126.3	128.5	130.7	133.0	135.2
23	116.4	118.6	120.8	123.0	125.2	127.5	129.7	132.0	134.3	136.7	139.0	141.4
24	121.5	123.8	126.0	128.3	130.7	133.0	135.4	137.8	140.2	142.6	145.0	147.5
25	126.6	128.9	131.3	133.7	136.1	138.6	141.0	143.5	146.0	148.5	151.1	153.7
26	131.6	134.1	136.5	139.0	141.6	144.1	146.7	149.2	151.8	154.5	157.1	159.8
27	136.7	139.2	141.8	144.4	147.0	149.6	152.3	155.0	157.7	160.4	163.2	165.9
28	141.8	144.4	147.0	149.7	152.4	155.2	157.9	160.7	163.5	166.4	169.2	172.1
29	146.8	149.5	152.3	155.1	157.9	160.7	163.6	166.5	169.4	172.3	175.3	178.2
30	151.9	154.7	157.6	160.4	163.3	166.3	169.2	172.2	175.2	178.2	181.3	184.4
31	156.9	159.9	162.8	165.8	168.8	171.8	174.9	177.9	181.0	184.2	187.3	190.5
32	162.0	165.0	168.1	171.1	174.2	177.3	180.5	183.7	186.9	190.1	193.4	196.7
33	167.1	170.2	173.3	176.5	179.7	182.9	186.1	189.4	192.7	196.1	199.4	202.8
34	172.1	175.3	178.6	181.8	185.1	188.4	191.8	195.2	198.6	202.0	205.5	209.0
35	177.2	180.6	183.8	187.1	190.6	194.0	197.4	200.9	204.4	207.9	211.5	215.1
36	182.3	185.6	189.1	192.5	196.0	199.5	203.1	206.6	210.2	213.9	217.6	221.3
37	187.3	190.8	194.3	197.9	201.4	205.1	208.7	212.4	216.1	219.8	223.6	227.4
38	192.4	196.0	199.6	203.2	206.9	210.6	214.3	218.1	221.9	225.8	229.6	233.6
39	197.4	201.1	204.8	208.6	212.3	216.1	220.0	223.9	227.8	231.7	235.7	239.7
40	202.5	206.3	210.1	213.9	217.8	221.7	225.6	229.6	233.6	237.7	241.7	245.9

CUBIC CONTENTS OF ROUND LOGS = $\left(\frac{\text{Girth}}{4}\right)^2$, in Cubic Feet and Decimals of 1 Cubic Foot.

Length in feet.	Mean Girth in Feet and Inches.											
	10′	10′-1″	10′-2″	10′-3″	10′-4″	10′-5″	10′-6″	10′-7″	10′-8″	10′-9″	10′-10″	10′-11″
10	62.5	63.5	64.6	65.7	66.7	67.8	68.9	70.0	71.1	72.2	73.4	74.6
11	68.8	69.9	71.1	72.2	73.4	74.6	75.8	77.0	78.2	79.4	80.7	81.9
12	75.0	76.3	77.5	78.8	80.1	81.4	82.7	84.0	85.3	86.7	88.0	89.4
13	81.3	82.6	84.0	85.4	86.8	88.2	89.6	91.0	92.4	93.9	95.4	96.8
14	87.5	89.0	90.4	91.9	93.4	94.9	96.5	98.0	99.6	101.1	102.7	104.3
15	93.8	95.3	96.9	98.5	100.1	101.7	103.4	105.0	106.7	108.3	110.0	111.7
16	100.0	101.7	103.4	105.1	106.8	108.5	110.2	112.0	113.8	115.6	117.4	119.2
17	106.3	108.0	109.8	111.6	113.5	115.3	117.1	119.0	120.9	122.8	124.7	126.6
18	112.5	113.4	116.3	118.2	120.1	122.1	124.0	126.0	128.0	130.0	132.0	134.1
19	118.8	120.7	122.7	124.8	126.8	128.9	130.9	133.0	135.1	137.2	139.4	141.5
20	125.0	127.1	129.2	131.3	133.5	135.6	137.8	140.0	142.2	144.5	146.7	149.0
21	131.3	133.4	135.7	137.9	140.1	142.4	144.7	147.0	149.3	151.7	154.0	156.4
22	137.5	139.8	142.1	144.5	146.8	149.2	151.6	154.0	156.4	158.9	161.4	163.9
23	143.8	146.2	148.6	151.0	153.5	156.0	158.5	161.0	163.6	166.1	168.7	171.3
24	150.0	152.5	155.0	157.6	160.2	162.8	165.4	168.0	170.7	173.3	176.0	178.8
25	156.3	158.9	161.5	164.2	166.8	169.5	172.3	175.0	177.8	180.6	183.4	186.2
26	162.5	165.2	168.8	170.7	173.5	176.3	179.2	182.0	184.9	187.8	190.7	193.7
27	168.8	171.6	174.4	177.3	180.2	183.1	186.0	189.0	192.0	195.0	198.0	201.1
28	175.0	177.9	180.9	183.9	186.9	189.9	192.9	196.0	199.1	202.2	205.4	208.6
29	181.3	184.3	187.3	190.4	193.5	196.7	199.8	203.0	206.2	209.5	212.7	216.0
30	187.5	190.6	193.8	197.0	200.2	203.5	206.7	210.0	213.3	216.7	220.1	223.5
31	193.8	197.0	200.3	203.6	206.9	210.2	213.6	217.0	220.4	223.9	227.4	230.9
32	200.0	203.3	206.2	210.1	213.6	217.0	220.5	224.0	227.6	231.1	234.7	238.3
33	206.3	209.7	213.2	216.7	220.2	223.8	227.4	231.0	234.7	238.3	242.1	245.8
34	212.5	216.1	219.6	223.3	226.9	230.6	234.3	238.0	241.8	245.6	249.4	253.2
35	218.8	222.4	226.1	229.8	233.6	237.4	241.2	245.0	248.9	252.8	256.7	260.7
36	225.0	228.8	232.6	236.4	240.2	244.1	248.1	252.0	256.0	260.0	264.1	268.1
37	231.3	235.1	239.0	243.0	246.9	250.9	255.0	259.0	263.1	267.2	271.4	275.6
38	237.5	241.5	245.5	245.5	253.6	257.7	261.8	266.0	270.2	274.5	278.7	283.0
39	243.8	247.8	251.9	256.1	260.3	264.5	268.7	273.0	277.3	281.7	286.1	290.5
40	250.0	254.2	258.4	262.7	266.9	271.3	275.6	280.0	284.4	288.9	293.4	297.9

Valuation of Arboricultural or Ornamental Plantations.—For the valuation of arboricultural plantations of full-grown trees, or, as it may be, a thinning of trees from a plantation, the author was wont to provide himself with a large passbook, containing the usual money columns on the right-hand side of each page, and having the spaces on the left-hand side of the money columns divided into four equal parts, parallel with them. The first space on the left-hand side was for entering the numbers to correspond with those intended to be marked upon the trees; the second, for entering the species of each tree as it was numbered; the third, for entering the number of cubic feet contained in the tree when marked; whilst the fourth contained the price per cubic foot of each tree numbered. The following example of this form of book will exhibit its details more particularly:—

Number of each tree.	Species of each tree.	Cubic feet in each tree.	Price per foot of each tree.		Value.		
			s.	d.	£	s.	d.
1	Oak	90	3	6	15	15	0
2	"	30	2	6	3	15	0
3	Ash	82	2	0	8	4	0
4	"	20	1	6	1	10	0
5	Elm	73	2	0	7	6	0
6	"	30	1	8	2	10	0
7	Beech	75	1	6	5	12	6
8	"	25	0	10	1	0	10
9	Plane	87	3	0	13	1	0
10	"	26	1	6	1	19	0
11	Larch	64	2	0	6	8	0
12	"	32	1	4	2	2	8
13	Scots Fir	58	1	6	4	7	0
14	"	18	1	0	0	18	0

In the act of valuing trees in the forest, he usually left the money columns blank until he had completed the work, or at least until after returning home in the evening, when he had leisure to fill the spaces in correctly. Having provided himself with a book of the above description, with the numbers filled in, and the uses of the columns written along the top of each page, he next engaged three men of active habits, each provided with an *iron* adapted for the marking of figures upon the bark of trees. One of the men began by marking No. 1 upon the first tree to be valued, a second man marked No. 2, and a third No. 3; and in this manner the three men continued following one another, each of them marking his own series of numbers in succession upon different trees.

Thus the first man marked 1, 4, 7, 10, 13, 16, &c.;
whilst the second " 2, 5, 8, 11, 14, 17, &c.;
and the third " 3, 6, 9, 12, 15, 18, &c.

When the men had got well into their work of marking the trees, the author next commenced valuing the tree having the mark No. 1 upon it, and writing opposite the same number in his book the species of the tree; next, the number of cubic feet that he estimated it to contain; and lastly, the price per cubic foot of each tree, according to his estimate of what it would really bring in the market at the time of valuation. In the same manner he proceeded with the valuation of each individual stem.

The author would remark here that every valuator of growing timber, previous to entering upon the valuation of it in any locality with which he is not well acquainted, should in all cases make himself properly conversant with the general prices of wood in that district; for, unless he does this, he will unquestionably commit considerable errors in his work. If, for instance, a valuator were to be called from Edinburgh to value wood in any inland district, from which it had to be carried a long way to market, and he proceeded to value the same according to the rate of wood-sales in the neighbourhood of Edinburgh, his valuation would of course be much too high; because in any inland district there is comparatively little local demand for wood. Before such wood could be sold, it would require to be carted by the purchaser for a considerable distance to some railway station whence it could be taken to a market; hence the valuator should always regulate his estimates according to the prices that he knows will be given at the nearest market, after deducting the expenses which will be necessary to carry the timber between the place where it is growing and the market where it is to be sold.

This method of valuing standing timber can only be held to apply to purely arboricultural crops. In all woods managed on sylvicultural principles, the Continental methods briefly sketched by the editor unquestionably deserve the preference. They are therefore now strongly recommended to the notice of foresters and timber valuators throughout Great Britain and Ireland.

NOTE.—*In order to obtain data for the compilation of more reliable tables than now exist in Britain, as to height, girth, increment, and average yield of the different kinds of woodland crops at various ages, and on the various classes of soil and situation, the editor would here invite the co-operation of Foresters and all interested in Forestry. Any authenticated data forwarded to him (c/o Messrs. Blackwood & Sons, 45 George Street, Edinburgh) will be gratefully accepted with a view to incorporation in the next edition of this work.*

CHAPTER XIV.

THE PREPARATION OF WORKING PLANS.

Disposal of Mature Crops of Timber.—Like agricultural produce, sylvicultural crops should be disposed of as soon as they become mature, and before they begin to deteriorate in value. This principle does not apply to purely arboricultural crops reared mainly for ornamental purposes, but only to such as have been formed and treated on sound sylvicultural, financial, and economic methods.

That timber should be disposed of to the best advantage whenever it has become mature, is generally admitted by landed proprietors; but they very often apply this principle without judgment, and therefore to their own loss. Thus healthy crops, increasing annually in value, are often utilised prematurely, simply because they have attained a certain age, and are therefore considered mature; while, on the other hand, other timber-crops are frequently left standing, although they may really have been deteriorating in value for many years, simply because they have not attained the usual age at which the species attains maturity under average circumstances as to soil and situation.[1]

No hard and fast statement can be given as to the age at which any specific crops of trees arrive at maturity; for all depends upon the nature of the soil and situation in which they grow, and upon the treatment they may have hitherto received. Birch, Aspen, Poplar, and Willow often yield their best returns when cut out from among other trees at 30 to 50 years of age. Ash, Sycamore, and Maple may often be quite mature when only about 60 to 70 years of age; while Oak should still be in a healthy progressive state at 120 to 140 years. And when trees grow upon a light soil, or are drawn up in a crowded condition, they culminate in productive capacity at an earlier age than when growing upon a heavy loam, or when the woods have been well attended to in the way of thinning. Larch grown on a wet,

[1] See extract from Loudon's *Arboretum et Fruticetum Britannicum*, 1838, vol. iii. p. 1809, already given on p. 364.

uncongenial soil sometimes matures under 30 years of age; while, on the other hand, it may remain in healthy growth till upwards of 100 years of age. Although all the land in Strathspey and Braemar may be said to be naturally well adapted to the healthy growth of the Scots Pine, still even there it may be found mature at all ages between 60 and 200 years, according to the individual nature of the crops. These facts show that maturity depends in each special case—

(1.) Upon the species of tree.
(2.) Upon the nature of the soil and situation; and
(3.) Upon the previous treatment the crop may have received.

As has already been previously remarked in different parts of this work, the treatment accorded to growing crops determines, to a great extent, both the age at which they attain maturity, and their marketable value when mature. And it is chiefly by means of thinning in a rational manner—*i.e.*, not in the arboricultural manner largely practised in Britain, but according to the Continental methods—that we possess the means of maintaining the health of the crop, of stimulating its production of timber, and of enhancing its technical and financial value.

In examining a plantation, then, with the view of ascertaining whether its crop is still making progress sufficient to warrant its being kept standing, or whether its clearance is necessary in order to realise the highest annual average returns possible from the land, the first point is to examine the general progress the crops have made during the last four to six years. If it be found that the average total increment in cubic contents is not satisfactory, this is a strong proof that the trees should be felled and converted into money; for they cannot possibly increase in bulk to such an extent as to yield a suitable interest on their present value. If, however, on examination, it be found that the annual increment in cubic contents during the previous four or six years is satisfactory, then it would be premature to fell the trees, as this would be an indication that they are still making such an annual addition to their value as will justify their being kept standing for some years longer. Another point which should be attended to in examining a crop of trees, with the view of learning whether they are matured or not, is the state of the foliage. On all trees in a healthy condition, and making considerable progress in growth, the leaves are large—according to species—fresh, and plentifully distributed on the young shoots; while, on such as are fully mature, they are small, not particularly well developed, and rather apt to be thinly distributed. There is still another point worthy of remark on this subject. The leader or top shoot of the stem of a tree invariably makes considerable annual progress upwards, so long as the rate of growth in height has not culminated; but, when once the normal height of the tree has been attained, the top shoot

ceases to make progress, and the crown gradually becomes flat-topped and of a broad-headed character. This last feature is more particularly observable in the Pine tribe of the Coniferæ. When once the rate of growth in height begins to sink, the energy of production is mainly confined to the formation of woody matter on the stem and the lower branches. Hence the top and the higher branches of a tree often indicate the general condition of the tree sooner than the lower portions.

From the general characteristics presented by growing trees as to health and rate of growth, the author thinks any intelligent man may be able readily to distinguish trees that are mature and those that are still in vigorous condition. He would, however, remark that a great loss is at all times sustained by the proprietor who cuts his timber-trees before they are matured, as in such a case the crop is adding to its value every year. But, on the other hand, there is as great a loss sustained by the owner who does not cut his timber till it is over-matured. In this latter case the timber is much inferior in quality, and consequently has a considerably less market value. Hence the most satisfactory course, both for the landowner and for the timber purchaser, is to decide upon disposing of a crop of trees before it attains a condition which may make the quality of the timber doubtful. It is perhaps not generally known or understood that as soon as trees have arrived at the stage of maturity indicated by great shrinkage in the rate of increment, and by a very spare clothing of foliage, their timber is in a state of slow decomposition—not, perhaps, observable to the inexperienced eye, although it is to one accustomed to examine it with a magnifying power. Hence this very advanced stage of maturity of the trees should never be allowed to present itself where sound timber is an object, and where the highest possible price is expected for a crop of it.

Supposing that a satisfactory examination has been made of a crop of trees, and that it has been found that portions of it are fully mature, but not over-mature, here and there; that other portions are so far advanced towards senility as to be deteriorating in value; and that on several parts the crops are still making considerable progress. Now these features with regard to a crop of trees may often be found in many plantations of any considerable extent, whatever the kind of tree may be; for in no enclosure do the trees all grow alike, and arrive at maturity at the same time. So far as the maturity of even the same kind of tree is concerned, very much depends upon the nature of different portions of the soil, and upon the difference of the aspect, &c., &c. In such a case, therefore, the author would suggest that although a portion, even to the extent of nearly one-half the crop, were in such a state as to justify its being retained for a time, still, from the fact of the other half being partly quite matured and partly

over-matured, there is the probability of a much greater loss being incurred by allowing the matured trees to remain till the others may attain full proportions than could possibly be made up by the increase of their growth; hence he would have no hesitation in recommending that the whole crop should be cleared and realised. It may indeed be argued that it would be better in such a case to dispose of the matured portions, and to leave the growing portions to improve. This, at the first glance, seems indeed reasonable, and in the case of hedgerow and park trees would be sound practice; but in the case of trees forming a plantation collectively, the author considers that the plan would not be in accordance with good management. Were the matured portions cleared, and the portions which were making progress left, the latter would, he is of opinion, be sure to become impaired in health and stunted immediately after they were exposed by the removal of the other trees from near them; hence the best policy in all such cases is to decide at once on clearing the whole crop. He recommends this from his own experience in dealing with the clearing of such plantations; and he does so from a full conviction of this mode being the most profitable in the end.

In previous editions of this work the author was under the impression that the **rate of growth in height** during the past five or six years was a good index as to whether plantations were "*mature*" or not. This is, however, not consistent with the laws regulating the growth of trees when forming woodland crops that are maintained in normal density during the younger stages of growth, and that are managed on purely sylvicultural principles. For the **rate of growth in height** culminates at a comparatively early period in the life-history of the crop; and long after that point of time the **rate of growth in girth** may continue to be vigorous. The latter will not necessarily culminate until very long after the former has begun to sink.

Thus, whilst on average classes of soil in Germany (see *British Forest Trees*, pp. 37 and 45) the **rate of growth in height** culminates—

For Beech	about the	40th	year	of age.
" Silver Fir	"	40th	"	"
" Spruce	"	45th	"	"
" Scots Pine	"	49th	"	"

yet the **current annual increment or rate of growth in cubic contents** culminates—

For Beech	about the	60th	year	of age.
" Silver Fir	"	50th	"	"
" Spruce	"	50th	"	"
" Scots Pine	"	20th	"	"

whilst the **average annual increment in cubic contents** only culminates—

For Beech	about the	100th	year	of age.
" Silver Fir	"	80th	"	"
" Spruce	"	70th	"	"
" Scots Pine	"	40th	"	"

And even these latter data, which are far more sound and reliable than the mere rate of growth in height, are no criterion to adopt for practical purposes. Even after the average annual total increment may have culminated, the timber crops may be still advancing steadily and profitably with regard to **qualitative increment**, in respect to the dimensions of the wood at the top-end of the bole; and as this qualitative increment determines the adaptability of the timber for technical purposes, it of course affects the marketable value to a very considerable extent.

So far as the nett returns derivable from any given soil, situation, and crop are concerned, they may be most correctly calculated by means of the following formula:—

$$\frac{Fc + Ta + Tb + \ldots\ldots Tq - (c + fv)}{f}$$

Here

Fc = the value of the yield of timber obtained at the **final clearance**.

$T(a, b, \ldots q)$ = the value of **thinnings** carried out in the years a, b, . . . q, calculated at compound interest up to the date of the final clearance.

c = the outlay for **cultural costs**, calculated at compound interest.

v = the **various annual outlays**, *e.g.*, protection, rates, &c., calculated at compound interest.

f = the number of years included in the **fall or period of rotation of the crop**.

Whatever calculations, made by means of the above formula, exhibit the largest nett result, they will at the same time distinctly indicate the year in which the best financial effect is attainable by utilisation of the timber crop.

In each concrete case, the requisite data for making calculations of the above nature must be obtained from the Estate Register (see pp. 408 and 428) so far as past actuals with regard to thinnings are concerned,—and either from actual measurements of sample plots, or from the average outturn shown by Yield Tables (as explained in chapter xiii.), with regard to the final yield of timber that may be expected from the crop judging from its present appearance and rate of growth. But when the most profitable time for the fall is being thus calculated, the rate of interest at which the forester or landowner works out the problem is of enormous influence in affecting the results. Even as early as 1751, Thomas Culpepper pointed out that if the ordinary rates of interest (which were then about 10 per cent.) were insisted on for crops of growing timber, no one could afford to allow woodland crops to attain the maturity that was requisite in the interests of the Commonweal. As Professor Endres remarks (Article *Forsten* in *Handwörterbuch der Staatswissenschaften*, Jena, 1892, p. 602):—

"The present rate of interest for forests in Germany lies between 2 and 3 per cent. With the timber prices now ruling, and the general economical conditions obtaining, a higher rate of interest simply cannot be obtained. Whoever wishes to grow woodland crops, must therefore be content with that rate of interest."

As the editor has elsewhere explained (*Studies in Forestry*, p. 3), it seems to him that about 2½ per cent. is the correct rate of interest that should be used as the basis for actuarial calculations with reference to woodland crops throughout Great Britain and Ireland.

The **financial or mercantile maturity** is what ought distinctly to regulate all felling operations in Britain; and this is a maturity which does not necessarily culminate along with the average annual total increment.

In fact, in well-managed crops of high timber the monetary increment may only commence to be most energetic long after the average annual rate of growth in height and rate of growth in girth have culminated, and when the average annual increment in cubic contents has already begun to sink perceptibly. The **purely technical maturity** of timber crops need be no concern of private landowners, although it was a very important matter in the State forests during the last century; and wherever this would indicate a prolongation of the fall or period of rotation beyond that pointed out by the financial formula above given, it ought not to be aimed at by private individuals.

The practical advice given by the author in the concluding portion of the text can hardly be endorsed by the editor. In fact, wherever there seems any good opportunity for stimulating the increment of the trees approaching maturity by the **method of partial clearance**, then this offers a most excellent opportunity of rapidly obtaining more remunerative returns from the crop. This method of partial clearance has been frequently described under the different species of trees in chapters ii. and iii., and again in chapter viii. relating to the tending of woodlands.

Concerning the Formation of Working Plans.[1]—It is almost impossible that any large tract of woodland can be managed in the most economic manner, and that the productivity of the soil can be fully utilised, unless the whole management of the woods is subject to administration of a regular order. This is only possible when a formal **Working Plan** has been carefully drawn up for the wooded portions of the estate, and when all the operations of regeneration, felling, sowing, planting, weeding and cleaning, thinning, selling, &c., are carried out annually in accordance with the intentions expressed in the working plan,—unless, of course, its provisions have been interfered with by any unforeseen circumstances.

The object of the working plan is, so far as possible, to provide for the continuous yield of annual returns of about equal extent and value, and, so far as is practicable, from about equal areas. Whilst this ruling idea is subordinated to the first fundamental principle of sylviculture—viz., that the form of management must be a truly economic method capable of maintaining the productive capacity of the soil—yet the details as to species of trees forming the crops, methods of treatment to be accorded to these, and most advantageous time and manner of utilising and reproducing the crop, are all to a very great extent dependent on local circumstances with regard to soil and situation, nature of local markets, &c. Hence no hard and fast rules are applicable to this any more than to the other operations of practical forestry. It is precisely in framing a good working plan that the shrewdness and the administrative capacity of the intelligent and observant forester find the best scope for exhibiting themselves.

Throughout all the State forests of Germany, Austria, and France, the whole of the annual operations are conducted in strict accordance with the provisions of such working plans; and, even in India, fellings within the Reserved Forests are not now allowed before working plans for their administration have been drawn up and approved by the head of the Department and by the Local Government, then formally submitted to the Inspector-General, and finally sanctioned by the Government of India. This latter fact is here mentioned merely in order to exhibit the importance that is attached to them even in India, where work is, and must long continue to be, more *extensive*

[1] See also vol. i. chap. i. p. 58.

than *intensive*. This might easily, and should, be the case also in Great Britain and Ireland. All more or less haphazard fellings should be put a stop to, and the annual operations subjected to a well-considered and careful working plan, which should forecast the general scope, extent, and method of all the ordinary work, so as so produce the highest economic and financial results that can be obtained from the given soil, situation, and general local circumstances.

This is a most important branch of Practical Forestry, but one which has not hitherto received anything like due recognition throughout Britain, owing to the woodlands being, in the vast majority of cases, treated *arboriculturally* in place of *sylviculturally*. Thus, when a tour was made throughout the Scottish and English woodlands in the summer of 1885 by the students of the *Ecole Forestière* from Nancy, the following remarks were made on the prevailing system (or rather want of system) of management by M. Boppe, who was at the head of the party, and who was asked officially if he would be good enough to submit in writing his views regarding Forestry in Britain:[1]—

"The productive powers of the soil and of the climate have been made use of by able and intelligent planters, who have thereby enabled nature herself to accumulate a considerable store of timber; but all this wealth is exposed to the carelessness of some, and to the ignorance of others, until the hand of a forester manages it properly and places it on the only sound economic principle of all agricultural and forest property—a constant annual revenue and a constant improvement in production. It would certainly not be fair to hold Scotch foresters responsible for the present regretable state of affairs; for though they have for the most part admitted the inefficiency of the present system, they are powerless to effect any improvement so long as the landowners and general public have not learned to appreciate the manifold advantages to be derived from a regular and methodical management. They have to struggle against many adverse interests and hindrances, such as grazing and shooting interests, questions of routine, pecuniary exigencies, and the fancies of sportsmen from all parts of the world.

. . . . . .

"Let the owner of a forest, after having made a careful and detailed inspection of it, divide it off into blocks or compartments, so arranged that they should be uniform as regards conditions of soil and of planting, and then proceed to count and measure all the trees of three feet girth and upwards, classing them in categories according to their diameter. He should then open a debit and credit account for each compartment, placing on the debit side the actual volume of the standing crop, and on the credit side the volume of timber removed at each successive felling. This register should always be consulted before undertaking any forest operation. Whenever the annual fellings fall due, it will show which compartments can best support the withdrawal of timber, and which require to be left untouched. Moreover, the balance sheet will render an exact account, favourable or otherwise, of the condition of the forest.

"Ten years of such systematic treatment would form in itself the basis of a regular forest working-plan."

The remainder of this chapter will be devoted to the consideration of this special subject, *firstly*, from the more or less *arboricultural* point of view taken up by the author in the last edition of this work; and, *secondly*,

[1] Appendix to Report of Committee on Forestry, 1885, p. 48.

from the purely *sylvicultural and financial* standpoint which the professional training of the editor on the Continent has instilled into all his thoughts regarding the treatment of woodlands. From a financial point of view these are merely investments of capital from which it is desired to obtain the highest annual returns continuously without prejudicing the intrinsic value of the soil, plus the growing stock, by injudicious treatment.

A.—The Arboricultural or British Method of Managing Woodlands.

I. **The Estate Register of the Growing Stock of Timber.**—It is a remarkable fact in the Arboriculture of Great Britain, that on very few estates in the country is there any register kept of the condition, age, kinds of trees, and present value of the crop of each plantation.

Every merchant, whatever he may deal in, draws up at the end of each year a statement showing the marketable value of the goods he has on hand from the trade of the previous year; and from this statement, together with the total of money realised, he is at once enabled to see whether his estate is increasing or decreasing in value. In consequence he is, to a certain extent, enabled to forecast his business arrangements for the following year. Every intelligent farmer acts on the same principle. At the end of the year, after his crops have been all secured, he draws up a statement showing the value of his crop and his stock; and from this he also is able to see at a glance whether his business is improving or otherwise. The landed proprietor, however, is not generally so particular in taking an inventory and making a valuation of all his goods at the end of each year. It is true, indeed, that his agent is always able to show him the clear income from the farming and mining interests of his property, and also that realised from his woods and plantations for the year; but as to taking a correct account of the real capital value of the latter investments as they stand upon the estate, that is seldom thought of. This is certainly a great mistake in the management of landed properties; and, as an improvement in this respect, the author would suggest that every landed proprietor should have a register of his woods and plantations, comprising all the useful information under the following headings:—

1. *The extent of land occupied by timber crops of less than* 5 *years' standing.*—This statement should show the details of each separate crop. This register should state the kinds of trees planted in each district respectively, the condition of the crops, and their actual cost of formation, stating both the outlay incurred, and the amount thereof calculated at compound interest up to the present or current year.

2. *The extent of land occupied by young timber crops of from* 5 *to*

10 *years of age.*—This register should show the age and kinds of trees planted in each separate crop that is included within the statement, the condition of the crops, when they may be expected to require weeding or clearing, when they will begin to yield profitable returns by the sale of produce removed from them on the commencement of thinning, and also their original cost, and the actual cost of formation calculated up to the present.

3. *The extent of land occupied by young crops of from* 10 *to* 15 *years of age.*—This statement should show the age and probable number of trees of each kind, and should state, with regard to each crop, the number that will fall to be removed at each periodical thinning, and the returns anticipated therefrom. The register should also detail the condition of the various crops, their original cost, their present cost, and their present prospective market value as well as can now be estimated.

4. *The extent of land occupied by crops between* 15 *and* 20 *years of age.*—This statement should exhibit the same particulars with respect to each crop as have been detailed under 3.

5. *The extent of land occupied by the pole-forest crops between* 20 *and* 30 *years of age.*—This register should show the age and number of trees in each separate crop, the number that will fall to be removed at each periodical thinning, and their estimated value, together with the general condition of the respective crops, and their present prospective market value.

6. *The extent of land occupied by pole-forest crops between* 30 *and* 40 *years of age.*—This register should show all the particulars with regard to each separate crop in the same manner as under 5.

7. *The extent of land occupied by older pole-forest or young tree-crops between* 40 *and* 50 *years of age.*—This statement should give similar particulars with regard to each crop as has been detailed with regard to 5.

8. *The extent of land occupied by tree-crops between* 50 *and* 60 *years of age.*—This should give the same particulars for each crop as under 5.

9. *The extent of land occupied by older tree-crops approaching maturity, and matured trees.*—The age and number of each kind should be detailed, together with the total number of trees in all, and their estimated or probable market value.

10. *Value of trees growing in the park.*—That of each individual tree should be shown separately; and remarks should be added indicating those that are healthy and still improving, and those that are matured, together with the age of each specimen, if known.

Any proprietor of woods in possession of such a register of his capital invested in the soil and the growing stock, as is indicated in

the above conspectus—provided that it be carefully and correctly drawn up—would at any time be able to ascertain the precise value of this class of his property. But, without such a detailed register, the value of his woods must always remain something vague and indefinite —an investment, the amount of which he can only calculate roughly by means of the nett annual returns received on the average during the last five or ten years, though these may, for actuarial purposes, be capitalised at any given rate of interest which he may be inclined to think the capital invested in land and timber actually yields. Such a register, dealing with the whole of the woods on an estate, would, however, give the proprietor a clear and reliable insight as to the probable value of his woodlands. It would also enable him to scrutinise all proposed operations in such a way as to be prepared to see whether his forester was carefully managing this branch of the rural economy of his estate. In short, with such a register once drawn up and corrected carefully at periods of five years, so as to form an account of all the timber-stock on the estate, the proprietor would know not only how much timber was, or ought to be, in each separate crop throughout his estate, but also the value of each crop separately and of the whole of the crops aggregately, whether with regard to the actual cost of formation calculated up to the present, or, in older crops, by estimating their future market value prospectively. And, at the same time, he would always be able to judge for himself as to the amount he ought to realise from his woods and plantations in each year, and would not be dependent on his law-agent or forester for such information. Finally, it would place him in a position which he cannot at present usually occupy with regard to criticising and forming correct opinions as to the quality or correctness of the estimates of revenue and expenditure annually submitted for his approval and sanction.

During the later years of the author's life, he drew up several registers of woodlands on various estates on the general principle here explained, and these appear to have given satisfaction to the proprietors concerned. With clear data at hand, the latter are now in possession of such information with regard to their timber-crops as enables them to deal with these in a clear and intelligent manner, in whatever way the subject may be viewed; whereas previously they did not occupy such a favourable position for supervision. And further, it almost stands to reason that, until proprietors make themselves thoroughly acquainted with the real value of their woodlands in the manner pointed out, they cannot be expected to take that interest in them which their importance on the estate really demands from every intelligent and conscientious landowner.

In this department of Forestry the Germans are highly intelligent

and economical, as all of them who have woodlands keep correct accounts with respect to the trees in each of their several plantations. Hence they are easily able at any time to refer to the value of the trees on the average in any particular crop, to the value of any wood or plantation as a whole, and to the value of the capital invested in the soil and the growing stock in the aggregate. The author admires the intelligence and skill of the German foresters with respect to the points under notice, and is desirous that British foresters should be equally capable, economical, methodical, and accurate.

II. **Reporting on Woodlands.**—It seems to the author that reporting on the condition of, and framing working-plans as to the best mode of dealing with, the timber-crops upon woodland estates, by some one known to be well skilled in the management of woodlands, is too little attended to by the landed proprietors throughout Great Britain and Ireland. Were it otherwise, and were judicious instructions as to regular management properly carried out, then it would naturally follow that a great part of the woodlands of Britain would not still be seen in the present unprofitable state in which they most undoubtedly and unfortunately must be considered to be.

In travelling throughout both England and Scotland, the author has usually found the plantations on many estates still in an unthrifty condition. On making inquiry as to the proprietors, he has almost invariably ascertained that the woodlands were in the possession of comparatively small proprietors, who keep mere workmen to look after them. Such hands are put to fell trees when required, and to measure them for sale; but men of this class know very little of Forestry, properly speaking. Can any other result be expected from such a want of management than that the timber-crops, which these working-men have the practical charge of, should be in an unthrifty state? Can any proprietor expect that a man who is content to work in his woods for the wages of a labourer should be as good a forester and as profitable a servant as one that would require a much larger salary on account of superior education and professional training?[1]

In Forestry, as well as in all other branches of business, men should be paid according to their ability and technical skill; and it is in large establishments that men of the best abilities have most scope for their special qualifications. This statement is applicable generally, though there are sometimes exceptions; but in the common nature of things this will, as a rule, be found to hold good, and especially in regard to Forestry and the cognate branches of rural economy.

Hence the question very naturally arises, *How, then, in the general management of their properties, should small proprietors conduct them-*

[1] Compare vol. i. chap. i. pp. 51 and 54.

selves with regard to their foresters, since the extent of the woodlands will not admit of their employing men at a salary beyond what the income from the timber-crops will justify? The author's reply is that, other things being equal, a skilful man is always a more profitable servant in any business than one of an opposite character.

In illustration of this he may remark that if a landed proprietor has 500 acres of wood, he would, without doubt, realise a greater annual income from these by putting them into the hands of a man as forester at £100 a year, than if he were to intrust the management to any common working-man at £1 a week; for the man obtaining £100 would be—or at least ought to be—able to bring a greater degree of intelligence and of technical knowledge to bear upon all his operations than the working-man could reasonably be expected to have at his disposal.

In this practical fact lies all the difference between the profitable and unprofitable management of woodland estates. In the very mode of organising work within the woods, an intelligent forester will save a large percentage of expenditure compared with one who has not the requisite skill and training. This is independent of the fact that the former is also able to make better and more profitable sales of the produce than the latter; and this is of itself a means of enabling the landowner to pay the former a higher salary than he could afford to give to the latter class of servant.

The author has seen these practical differences exemplified in so many cases during his experience of more than thirty years, that he strongly urges every proprietor of woods either to secure the services of an intelligent forester, or else to keep none at all; for, in the latter case, it would often be preferable to employ a mere working-hand or labouring woodman, to act under the general directions of the proprietor himself, or one of his family, or his factor or agent.[1]

The author could give many examples in illustration of the correctness of this recommendation; but only one concrete case need be mentioned. Some years ago he was requested to inspect the plantations upon an estate, and was asked to submit a report on them for the future guidance of the forester. The plantations extended in all to about 350 acres, and were of ages varying from 15 to 50 years, with groups of hardwoods of greater age in the neighbourhood of the mansion-house. Owing to the death of the proprietor, the heir of the estate had been in minority for about ten years; and during

[1] At present there is no class of trained sylviculturists, who can be consulted or called in, in the same way as physicians or lawyers, to give advice regarding the management of woodlands, or to exercise a general and permanent supervision over the timber-crops on rural estates. This matter has, however, previously been adverted to by the editor in vol. i. chap. i. p. 60.

that time little or no thinning had been performed for the welfare of the timber-crops, either in the younger or the older plantations. As a whole, therefore, they were consequently found in a very unsatisfactory state indeed. Generally the crops—except on parts here and there, where trees of some size had been cut for estate purposes—were overcrowded, and had consequently become drawn up and weakly.

In his survey of the plantations he was accompanied by the man called the forester, who had been, and indeed was, a mere feller of trees when wanted for estate purposes, but who certainly knew the one sort of tree from the other. This man had no definite idea of the advantages of thinning or of draining with regard to the health and the development of the trees that had been for nearly twenty years under his care; and the result of his mismanagement was the unsatisfactory state in which the several plantations were actually found. From him it was ascertained (1.) that the late proprietor had practically conducted the management of the woods himself, for the purposes of recreation and amusement, (2.) that he personally marked the trees which were to be removed in the operations of thinning, and (3.) that the forester had only to fell stems which had been marked by the owner. There was, indeed, evidence of this in the condition of the several crops, as they seemed to have been well thinned at one time.

Here, now, was a case of mismanagement of the growing timber-crops owing to want of knowledge and intelligence in the man placed over them as forester. It clearly exemplifies the great loss that proprietors, in a number of cases, must naturally sustain by leaving their plantations in the hands of unqualified men. But, more specifically, this was a case in which the author found that the plantations,—which, had they been properly attended to, at their age ought to have had a crop worth about £40 per acre on the average,—were, in point of actual fact, not worth the half of this; and they, prospectively, had been rendered of comparatively small value.

What he desires to show from the foregoing is, that it would have been vastly more advantageous for this property had the trustees in whose charge it was left even paid several hundred pounds to a well-qualified forester per annum, than to have left the woods in the hands of the man whom they allowed to remain in charge of them, and from whose simple ignorance the plantations had been to a very considerable extent prejudiced with regard both to their present condition and their future value.

As the author found the forester then resident on the estate incapable of carrying out his recommendations for the improvement of the plantations, and as he saw that the income likely to be derived from them would not, at least for a number of years, well allow of a properly qualified man being constantly employed in them, he re-

commended (1.) that an expert woodman should be engaged to superintend the labourers engaged in the different works of thinning and draining as they fell to be performed, and (2.) that an experienced and well-qualified man should be called in to mark the trees to be removed as thinnings, and to project drainage schemes, as well as to give general specifications and instructions, consistently with the report submitted on the timber-crops, from time to time, as the different works required attention.

This case explains the meaning of the author's statement made on page 412, that "he strongly urges every proprietor of woods either to secure the services of an intelligent forester, or else to keep none at all." He has recommended the same mode of procedure—viz., to employ a common woodman who could receive instructions from an intelligent forester from time to time, to whom he should refer in all cases of seeming difficulty with regard to the woods—on many small properties which he was called upon to visit professionally, and where the proprietors did not take so much personal interest in the management and well-being of their woods as to induce them to see that the various points of the author's report should be carried out; and in all cases he understands that this method has given entire satisfaction.

By adopting such a mode of managing the woods on small properties, on which it would not pay to employ and retain a highly qualified man continuously, the woodman, who of course need only be a mere working-foreman set over the other hands, is in no way responsible for the management of the woods; he only works under the directions of the qualified man, to whom from time to time he looks for guidance, and whose check for badly performed work, or approval for good performance, keeps him at all times up to his duty, and requires him to see that matters are in proper order for inspection when controlling revisions are made from time to time.

With these preliminary remarks on the subject of the management of woods on small properties where a properly qualified forester cannot well be profitably maintained, the author would now proceed to describe how he has been in the habit of drawing up **Reports upon Woodlands**, for the guidance both of the proprietors themselves and of those intrusted with the charge of the growing-stock of timber. He might have entered on this at once, without making any preliminary remarks; but he thought it better to refer, in the first place, to the bad state in which plantations on small properties are often found, in order to bring out more clearly the great necessity that undoubtedly exists for every proprietor being furnished with a report on the management of his woods by some intelligent and skilful man in his profession. Without such a report, the works of thinning, draining, &c., &c., can never be carried out systematically; nor can

an income be realised with that degree of profit or satisfaction which the proprietor has a right to demand of the person into whose hands he intrusts the charge of his woods.

In the management of woods, as well as in that of any other branch of business, unless a definite and suitable code of rules and regulations be laid down, adapted to meet the nature of the subjects, the whole business is apt to get into disorder. Monetary transactions, both with regard to income and expenditure, may often result unsatisfactorily; and in any case want of regular method in the management is not only very unsatisfactory, but is also most frequently uneconomical and less profitable to the proprietor. To obviate such results with regard to the management of woodlands is the object of framing reports upon their condition and on the most suitable treatment to be accorded to them both for the present and in the future.

In reporting on the woodlands of any estate, the following various headings should be laid down by the reporter as a general guide in carrying out his task:—

1. A tabular statement showing the extent of the woodlands on the property, and stating the ages of the several crops.
2. The present condition of each separate crop, stating the average diameter of the trees in each case.
3. The nature of the past management under which the plantations have existed.
4. How far the several crops had been suited with regard to the different descriptions of land planted, stating the special character of the soil upon which each crop has been formed.
5. The timber crops which have made most progress at their respective ages, and the circumstances which have contributed to this state of the trees.
6. Those crops which are unhealthy or diseased, and the causes of the backward or bad development.
7. The particular method of treatment that should be adopted for the improvement of the timber crops generally.
8. General recommendations and specifications with regard to fencing.
9. The same with regard to the operations of drainage.
10. The same with regard to soil-preparation before replanting unoccupied areas in the existing plantations.
11. The same with regard to the formation of new timber-crops.
12. The same with regard to the mode of cleaning and weeding suitable for the youngest classes of crops.
13. The same with regard to the operations of thinning in thickets, pole-forests, and young tree-forests.
14. The same with regard to the pruning of older trees, and to partial clearances with simultaneous underplanting for the purpose of stimulating the trees approaching maturity to an enhanced rate of increment materially, technically, and financially.
15. The income which, under good management, may be annually derived from the capital invested in soil and growing stock.
16. The expenditure which, in all probability, will be annually required to carry out the improvements suggested, and to maintain the woodlands in proper condition.

17. How wood sales ought to be conducted on the property, taking the situation of the timber-crops and their distance from market into consideration.
18. Statement showing the probable nett income that may be anticipated during the next ten years. This statement should also be made to furnish the detail for each crop that will be harvested within these ten years.

Having thus specified in detail what seems to him the most important points calling for attention from any one who would undertake reporting on plantations, whether of a small or large extent, the author would next devote a few remarks to a short description of the manner in which the reporter should take up and illustrate each of these detailed points for the full benefit of the proprietor and of his forester. The various points are treated of seriatim as tabulated in the above classification.

1. In framing a register of the various crops, the reporter should be careful to make his tabular statement as comprehensive as possible; and he should at least embrace in it the following points, each of which should be stated under a separate column:—

(*a*) The name of each plantation;
(*b*) The character of the soil and subsoil;
(*c*) The nature of the underlying rock;
(*d*) The condition of the land previous to its having been planted;
(*e*) The extent in imperial acres;
(*f*) The character of the crop;
(*g*) Its age;
(*h*) Description of fence by which surrounded;
(*i*) The elevation above the sea.

A well-arranged statement of this sort will form a comprehensive description of each plantation, which will be found of great use both to the reporter himself, while he is engaged in the work of reporting, and to the proprietor and his forester for reference at any subsequent time.

2. In detailing the concrete condition of each crop, the reporter should prepare himself, by a careful examination, to give a particular account of the state in which he finds the crop in each plantation, paying special attention to the state of the trees, with reference to density of the leaf-canopy (if crowded, or normal, or thin), to any tendency to wetness or dryness of the soil, to the nature of the soil-covering (herbage, dead foliage, humus-layer). He should also note the state of the fences around each separate enclosure, the extent of drainage necessary to improve the various crops, and the probable value of each crop, both as regards the cost of formation increased at compound interest up to the present, and with respect to its prospective or probable future value judging from its present condition.

3. In adverting to past management he must be careful, as he proceeds, to make notes with reference to the health of the several crops, and to state whether the trees are suited to the land they occupy, or whether they are likely to attain good ultimate development as a marketable crop.

4. In summarising under this head, of course, the report will follow the general tone previously expressed with reference to the several crops which go to form the whole growing stock.

5. In singling out the best of the timber-crops for special mention, the reporter should previously have prepared himself for specifying them by making judicious notes whilst examining the various individual crops, more particularly with reference to any that seem to him exceptionally good for their age. These notes will also be useful as illustrative facts when formulating his general recommendations for improvements requisite in the management of the whole growing stock; and he should be careful to show the cause of certain crops being better than others of the same age, &c.

6. With regard to backward or diseased crops, it need only be here remarked that the reporter should be as careful to state the causes of the inferior development or disease under this heading, as he previously has been in accounting for the greater vigour and healthier development of the crops singled out for special mention under heading 5; because ample details under both of these heads are necessary for the information and guidance of the proprietor and of his forester.

7. Although all the headings set forth for detailed description, at one part or another of the report, are absolutely necessary in order to frame a proper and useful working-plan for the woods, still it may safely be stated that the section now being considered is the most important. It should therefore be drawn up in the most minute, careful, and intelligible manner. Upon the accurate statement and classification of all the well-considered suggestions for the present and subsequent guidance of the forester in all the different branches of his work, the real utility derivable from such a report depends. This subject should therefore be carefully taken up and discussed; and a judicious method of treatment should be laid down in full but not unnecessary detail, for the guidance of the proprietor who is employing the reporter.

8. No comment need be made with regard to that section of the report which deals with the fencing of enclosures.[1] It should

[1] The opportunity may here be taken of calling the attention of the student to a report *On the Various Modes of Enclosing Plantations* in the *Trans. Scot. Arbor. Socy.*, vol. ix., 1879, pp. 199–216.

be short and clear, and should contain any detailed recommendations that suggest themselves with reference to the nature or given circumstances of that particular part of the country.

9. The section treating of drainage operations is also a very important one, which should be carefully attended to by the reporter. Especially reference ought to be made to details such as the depth of and the distance between the drains, under due consideration of the nature of the land. He should also note the probable expense of the drains to be made in each separate enclosure, and the extent to which he considers them necessary in each case. He should likewise draw up a statement showing the particulars of all drainage operations he proposes for the improvement of the crop of each enclosure.

10. A tabular statement should be drawn up with reference to the drainage requisite for the plots to be planted up. In this should be exhibited the extent requiring to be replanted in each separate crop, the kinds of plants to be used, and the expense of the operation. An explanation may also be given by the reporter of the results that may be expected from the outlay which he advises for each concrete case.

11. Under this section reference should be made to the drainage or soil-preparation requisite before proceeding with the planting of new enclosures. As this is a most important section, every particular with regard to the proper performance of the work should be clearly and intelligibly laid down, so that no two opinions may arise on any point afterwards. After giving details as to fencing, draining, trenching, ploughing, &c., the reporter should show *on a plan* the parts on which he considers the several kinds of trees ought to be planted, and should state *clearly and definitely* the proportion in which the various species of trees shall be admixed throughout each of the crops formed on different areas, as also the distance at which the young plants are to be planted out, the age of seedlings or transplants to be used, &c. &c.

12. Under this section reference must be made to the extent to which weedings and cleanings seem necessary for the improved development of the younger timber-crops.[1]

13. The section treating of the thinnings is also a very important one, and should on that account be treated in detail for the various crops. The reporter should give a specimen of his mode of thinning in each of the plantations he recommends to be thus operated on, and to these specimens he should make special reference in his report. He should, at the same time, give instructions as to the general

[1] The editor would here call attention to the technical distinction between *weedings and cleanings* and *thinnings*. It was previously pointed out in vol. i. chap. vii. p. 581; and in vol. ii. chap. x. pp. 132 *et seq.*

mode, and estimates relative to the expense, of the operation in reference to each separate crop, as well as any other particulars that occur to him on the subject.

14. So far as pruning is concerned, the author would merely remark that a judicious reporter, who understands his work, will usually be very guarded in recommending this operation as an improvement with respect to young trees; for there is, generally speaking, more harm done by pruning than advantage gained by it. Still the subject may often deserve attention; and in that case it should certainly be referred to.

15. The forecasting of the income that ought to be derivable from the woodlands forms, as it were, the estimate of the harvest of all the operations. Hence the greatest care should be taken to show the quantities of wood, bark, &c., that may be taken from each crop to be operated on in a given year, and their value according to present ruling prices in the neighbourhood. A proper tabular statement should be drawn up, showing the probable amount of income from each of the woods to be operated on during the year. In this the reporter should clearly state the grounds for arriving at his conclusions. He should, of course, carry this statement as to income over a given number of years, so that afterwards the proprietor may be able to ascertain from after results how far the reporter's estimate has proved itself correct.

16. The section dealing with expenditure is also equally important. The reporter should therefore be very exact and careful in making calculations with regard to it. Every item of expense should be noted, under its own proper head, as will be described in the succeeding chapter (see p. 435).

17. The system of disposing of the mature crops is a subject of very great importance with regard to reporting on woodlands, and should therefore be judiciously gone into. This subject should be taken up at such a length as to explain every particular necessary in order to show how the present prices of wood are affected by roads and distance from market, and how higher prices might be realised by adopting certain improvements in sales or in the mode of transit.

18. The concluding section of the report, exhibiting the nett income that ought to be derivable during the next ten years, should be in the form of a tabular statement, setting forth the points referred to. As the formulation of such a statement requires great judgment and experience, in order that it may prove a fairly correct and reliable approximation,—for absolute accuracy could not be reasonably expected,—none should attempt it who have not full confidence in their own experience. Any errors made in this respect will soon register themselves against the reputation of the reporter.

B.—The Sylvicultural or Continental Method of Managing Woodlands.

The leading feature of the Continental system of forest management consists in the pains there taken to ascertain, first of all, the exact productivity of the land and the actual quantity of wood growing in each crop, and then to forecast the annual fall of timber that ought to be annually obtainable *in perpetuo.* The working plans which are formed for guidance in this respect are usually, however, subjected to revisions once every ten years. During such revisions all the actual operations are checked with the original forecast; and any variations, of sufficient importance to necessitate modifications in the working plan, are duly considered and given practical effect to. The working plan forms, therefore, an index or guide that is prescribed after approval, and that must be followed as closely as possible in the general conduct of operations; but, of course, from the very nature of the dangers to which timber-crops are exposed, its provisions cannot always be adhered to in detail.

The general principles underlying the **working plan** are well expressed in the following extract from the U.S. Department of Agriculture, Forestry Division, Bulletin No. 5, 1891, *What is Forestry?* by B. E. Fernow, chief of the Division of Forestry, in which the **German method** is sketched:—

"**Working Plans.**—In making up working plans for a large forest area, considering the fact that the crop matures only in 60 to 150 years, more or less, it stands to reason that a general plan for the whole time of production, and a special working plan from year to year is necessary; and in planning, both technical and financial considerations must be consulted.

"For a forest administration on a large scale, and especially for a State forest administration, the management should produce from year to year about the same amount of revenue, and involve the same amount of expenditure.

"Especially is it desirable, although technically by no means necessary, that neither less nor more wood be cut than grows annually, so that there is a continuous production of about the same amount for ever.

"To determine what that amount is requires a considerable knowledge of the conditions of the forest and the rapidity with which the annual wood-growth accumulates.

"As stated before, it is not wood, but wood of a certain quality, and the largest amount at least expense per acre, that forest management is after. Now, the quality as well as the greatest quantity of wood is to be found in a tree of certain age, and while this age may vary for different kinds of trees and different localities, it is approximately determinable when it is most advantageous, alike for quality, quantity, and cost of production, to cut the tree or the forest. The time from the seedling stage to the mature tree ready for the axe is called the 'rotation.' If we say this Pine forest is managed under a rotation of 100 years, it means that we allow each tract to grow to 100 years before we cut the trees, or that we expect to return for a new crop within 100 years to the same acre we have just cut. Now, if we desire to cut an even amount every year, say, for instance, one acre of 100-year-old Pine, we would need to have 100 acres of Pine, each acre differing in age by one year.

"This would be an ideal or normal forest, in which we also suppose an equal annual normal accretion. In such a normal or ideal forest there must be at the outset a certain amount of wood standing, which is the stock upon which the yearly accretion accumulates, and may be called the normal stock

or normal reserve. It consists, of course, of the sum total of wood on each acre from the one-year-old to the 100-year-old, and its amount is readily figured out if we know the difference in amount of wood between each acre or the normal accretion per acre from year to year; for it is one-half this amount multiplied by the number of acres, or what is the same, the years of rotation. In our example, for instance, with a Pine forest, which we work under a 100-year's rotation, if we assume that there is an annual normal accretion of 50 cubic ft. per acre, the normal reserve would figure $100 \times 50 \div 2 = 2500$ cubic ft. per acre. This, then, is the average amount per acre which we should strive to keep in stock in order to ensure an equal annual amount of growth, or an equal annual cut.

"In reality this ideal, of course, is never reached; but it serves as a guide in the working plans, and the conception is a most important and useful one.

"Thus, in bringing a mismanaged forest-growth under management for continuity, we may find the stock of reserves to be either above or below the normal, and hence we may either cut more or less than the normal accretion, until the reserves are brought down, or up to, or near the ideal.

"The working plans must also include the propositions for improvement, for new cultures on denuded areas, &c. One of the most important improvements is the construction of properly situated and well-kept roads, or other means of transportation. In European forests the 'road-net,' as a rationally disposed system of roads is called, is considered of prime importance. Accessibility to markets, easy, cheap, and permanent means of transportation, furnish the keynote of profitable forest management.

"The method of marketing the crop is another matter of administrative consideration. This can be done either by selling the crop on the stump, or by shaping it and placing it on the market, either in the woods or in the stores.

"To the first method there is considerable objection, for the reason that in cutting for reproduction there is need of careful handling of the timber, and it requires much undesirable supervision if private parties do the logging, while the Administration, logging on its own account, can better control the manner in which it is done. In most European Administrations the cutting is done by the Administration; each log is measured and numbered, and each cord is also numbered, and after public announcement the wood cut in a certain district is sold at auction by numbers to the highest bidder, lumbermen and other wood consumers having an equal chance.

"The surveying and mapping and the districting, manner of employing labour, leasing privileges, &c., are other Administrative matters.

"This will be enough of the principles and detail of forest management to give an idea of what it is and what it involves."

In Austria the same principles hold good, although there are differences in the method of applying them. Thus the procedure prescribed for Hungary is as follows:[1]—

"**Working Plans.**—All the forests included in Class A (*i.e.*, State, Commercial, Corporation, and Trust Estates), being under the provisions of section 17 of the Forest Law, must, as before stated, be managed in accordance with the provisions of a working plan approved by the Minister of Agriculture. A period of five years, which expired on the 14th June 1884, was allowed for the submission of proposals on this subject; but up to that date very few had been received, and most of the proprietors have had to ask for the extension of three years, which can legally be granted when sufficient cause is shown. In as many as possible of these cases, however, the Minister of Agriculture has, in the manner prescribed by the law, approved

[1] Bailey, in *Trans. Royal Scot. Arbor. Soc.*, vol. xii. part i. p. 18, 1888.

of temporary plans to regulate work for the next few years. These plans have been prepared by the inspectors from data furnished by the proprietors.

"The regular working plan consists of three parts—

"1. *A Statement of the Present Condition of the Forest.*—This gives all information relative both to the forest itself and to its surroundings which is likely to influence the management—such as its situation, its owner, the rights of other persons in it; the wood market and export lines; the managers, guards, and workmen employed; the previous system of working, the results of survey, and valuation of the growing stock.

"2. *The Use to which the Forest is to be Devoted.*—This must be determined on the assumption that it is to give a constant annual yield for ever; but, subject to this condition, the wishes of the proprietor must be considered.

"3. *Management and Yield.*—This part of the working plan deals with the species to be cultivated, the system of management to be adopted, the revolution, manner of regeneration, and division into blocks and compartments, as well as the working out of the produce, and such like matters. The law lays down that the revolution for high-forest cannot be less than sixty years, and for simple coppice less than ten years. The annual cuttings are always to be determined by area, not by a consideration of the cubic contents of the stock and the rate of growth. All quantities of wood are to be expressed in cubic metres. The smallest scale permissible for the working map is $\frac{1}{144,000}$, or 4·4 in. to the mile. For small forests, not adapted to regular treatment, more simple working plans may be framed. For forests of protection the Minister of Agriculture determines the system of working; but there can be no clearing, clean-felling, nor collection of dead leaves, grass, or herbs within them, and, generally speaking, they are closed against grazing."

In **France** also this main branch of Forestry is guided by the same ruling principles, as may be seen from the following sketch, extracted from an article on *Forestry in France*:[1]—

"**Working Plans.**—Working plans or schemes will, in course of time, be prepared for all forests administered by the Forest Department. The law provides that all these forests shall be subjected to the provisions of such plans, and that no fellings which are not provided for therein, and no extraordinary cuttings, either from the Communal 'reserve' or in the blocks destined to grow from coppice to high-forest, shall be made without the express sanction, in each case, of the Government, by whom all plans must be approved before they can be adopted.

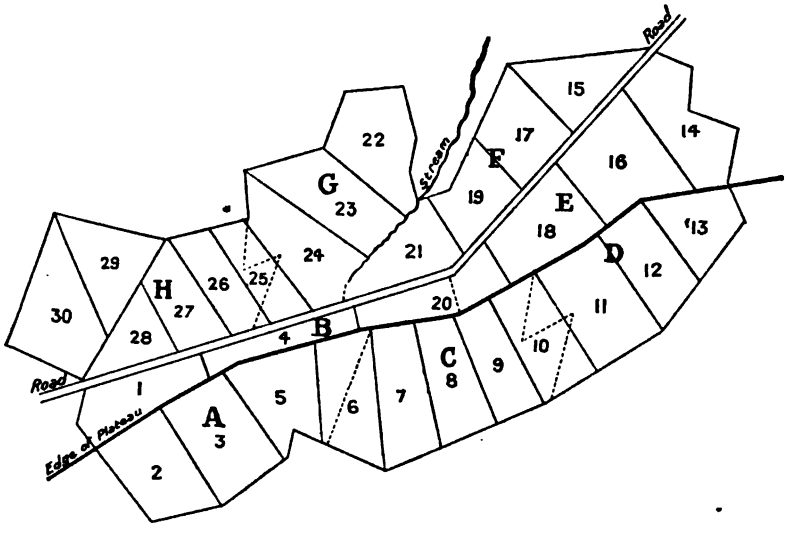
"Subject to due provision being made for the exercise of rights of user, the working plan provides for the management of the forest in the way that will best serve the interests of the proprietor. Unlike an agricultural crop, which ripens and is gathered annually, trees take many years to grow to a marketable size, the actual period that they require being dependent not only on their species and the natural conditions under which they are grown—as climate, soil, and so forth—but also on the use to which they are to be put. Thus, a coppice being required to yield wood of small size only, may be cut every twenty-five to forty years; whereas a high-forest, which is destined to produce large timber, must stand for a much longer time. It would be excessively inconvenient if the entire crop of such a forest were felled only once in every 100 or 150 years; and it is chiefly to avoid this that a working plan is required, which prescribes the arrangement necessary in order to allow of the produce being taken out annually, without intermission and in equal quantities, so that a regular and sustained income may be drawn from the forest. For example, a simple coppice thirty acres

[1] Bailey, in *Trans. Royal Scot. Arbor. Soc.*, vol. xi. part ii. p. 234, 1886.

in extent, of which the crop is to be felled at the age of thirty years, might either be entirely cut down at one time, and then allowed to grow up again for thirty years; or, which would be found much more convenient, it might be divided into thirty one-acre compartments, each of which is to be felled in succession, so that by taking one plot each year, the whole area would be worked over in thirty years. The working plan must then, in the first place, prescribe the age at which the trees are to be felled, with reference to the average number of years that they take to arrive at maturity or to attain the required size; and it must then fix the yield, or the amount of wood to be annually removed, this quantity being expressed either in the form of an area to be cut over, or a number of cubic feet of wood to be taken out. But in the case of a high-forest managed under the selection method, it is sufficient to fix the number of trees of a minimum size to be cut out annually.

"The provisions of a working plan vary according to the nature of

Fig. 345.



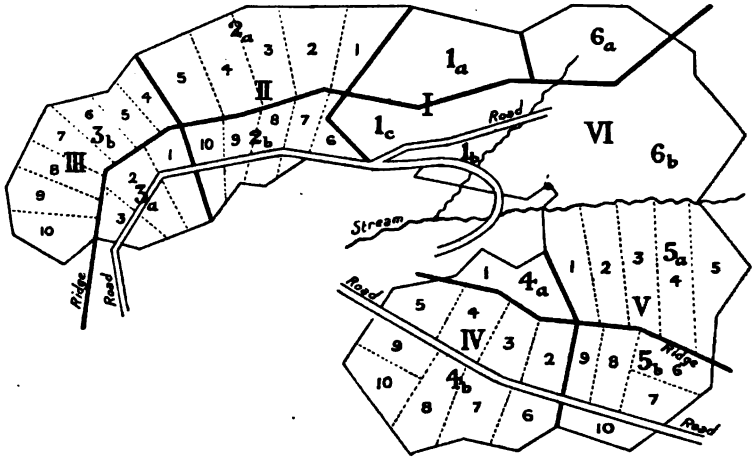
Simple Coppice.

the forest to which it relates. In the case of the **simple coppice** instanced above, the first thing to do would be to obtain a map (see Fig. 345) showing the principal features of the ground, such as the edge of the plateau, the stream, and the road. The area would then be broken up, for purposes of examination and description, into temporary plots, such as those lettered from (A) to (H), each plot comprising a portion of forest more or less homogeneous in its composition. This study of the crop would enable the area to be divided into the thirty permanent compartments above alluded to, and it would also determine the order in which they should be numbered, so that the older portions might be cut first. It is evident that if one of these be cut every year, the series of compartments will, after the lapse of thirty years, contain forest of all ages from one to thirty years; and if the annual felling be invariably made in the oldest compartment, it is evident that the age of the crop cut will always be thirty years.

"To make a working plan for a **regular high-forest**, to be treated

by successive thinnings, is not quite such a simple matter. If the forest is of great extent, it is, first of all, divided into two or more *series* or sections, each of which is dealt with separately. After the examination and description of the temporary plots, the section (see Fig. 346) is divided into a number of equal compartments called *affectations*, and when the ground has once been completely worked over, the crop on each of these will always be within certain limits, in the same stage of development, and subjected to the same kind of treatment. Thus, if the trees are to be felled at the age of 120 years, and there are six compartments, the sixth may contain the young growth, aged from 1 to 20 years, the fifth young poles from 21 to 40 years old, and so on, the first containing the old trees which are to be felled. The compartments having been formed, each of them is then subdivided into compartments usually corresponding in number with the years over which the fellings within it are spread (twenty in this case), and, while the trees are being cut in the first compartment, clearings and thinnings of various recognised degrees are going on in the

Fig. 346.



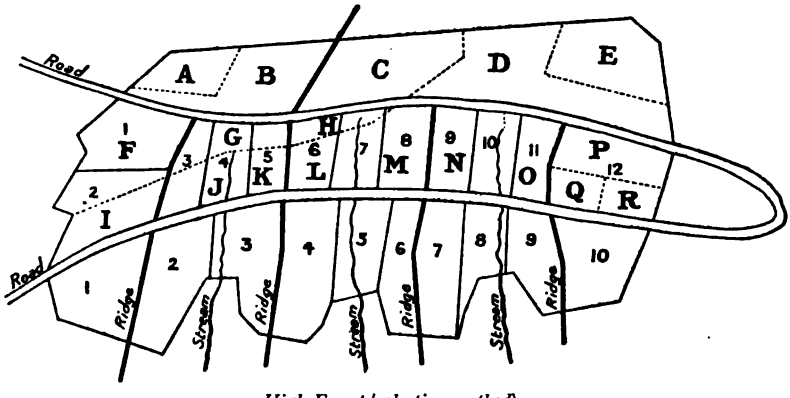
High-Forest (regular method).

compartments of the others, until each in its turn arrives at the age at which the trees are to be removed; and it is clear that in this case also the forest will ultimately contain a due proportion of trees of all ages from 1 to 120 years, which is an essential condition. The working plan prescribes the order in which all this is to be done, and it lays down the number of cubic feet of timber of the oldest class which are to be taken out annually from the first or oldest compartment, so that the entire stock on it may be removed within the first period of twenty years, windfalls and dead or dying trees being always taken first; each of the remaining compartments is similarly dealt with when its turn to be felled arrives. The quantity of wood to be removed by thinnings cannot be prescribed by the working plan, as they must be made to the extent which is judged necessary in order to develop the trees which are left. The forester's art is to do this skilfully, and ultimately to remove the old trees in such a manner that they may leave behind them a young self-sown crop to take their place, and so on throughout successive generations.

"For a high-forest to be managed under the selection method,

the arrangement is different. Here it is, of course, equally necessary that all the age classes should be represented in due proportion, but instead of the trees or poles of each class being grouped together in separate compartments, all classes are mixed indiscriminately over the entire area of the forest, and there is thus no necessity for the formation of *affectations* or compartments of the kind just described. Take, for instance, the mountain forest sketched in Fig. 347. After the main features, such as the streams, ridges, and roads, have been laid down on the map, the temporary plots and the descriptions of them are made as before. The forest might, in the present case, be divided into three sections, the upper of which, being on the crest of the hill, is required to be kept as dense as possible, and will not be dealt with in the working plan, as dead or dying trees alone will be removed from it. Suppose that the annual yield of the central section, which is 150 acres in extent, has been fixed, with reference to the estimated rate of growth and degree of completeness of the stock, at 50 cubic ft. per acre, and that trees of marketable girth within it contain on an average 100

Fig. 347.



High-Forest (selection method).

cubic ft. of timber, it follows that the number of such trees which may be removed annually from the section is $\frac{150 \text{ by } 50}{100} = 75$. Theoretically this number should be taken one here and one there over the whole area; but this would be very inconvenient, so the forest is divided into twelve or any other convenient number of equal or nearly equal blocks, from each of which, in succession, the entire number of trees is to be cut; after taking windfalls, the choice falls on the ripest trees, those which are dead or dying being selected first. The section below the road is in another zone of vegetation; it is 100 acres in extent, and its annual yield is calculated at the rate of 60 cubic ft. per acre. Suppose, then, that the trees of marketable girth contain on an average 110 cubic ft. of timber, the number of such trees to be cut annually is $\frac{100 \text{ by } 60}{110} = 54$. The section will then be divided into blocks,—in the instance illustrated by the map the number is ten,—from each of which in succession the entire number of trees is taken. In this manner each zone of altitude may be dealt with on its own merits, while, at the same time, the annual fellings, being localised, are easy to supervise, and the wood can be disposed of more readily and more profitably than if the trees had been felled here and there over the entire area. The

working plan for a forest under conversion would, of course, differ from any of the above; but this somewhat complicated question will not be dealt with here. It is only by an arrangement similar to one of those above briefly sketched that a permanent annual yield of a particular class of produce can be assured, and that the forest can be secured against the risk of gradual extinction.

"A special branch of the Forest Department is charged with the preparation of working plans, which are not made by the local officers, except in the case of small forests, the plans for which they can frame without interference with their ordinary duties; but they undertake the revisions, which are made every ten or fifteen years, in order to guard against errors, and to allow for changes in the rate of growth, or other causes of disturbance. Pending the preparation of such regular plans, the Forest Department draws up provisional rules, which must accord with local usages, where these are not opposed to the recognised principles of sylviculture. Up to the beginning of 1877 regular working plans had been completed for more than two-thirds of the total area of the State forests, and for somewhat less than one-half of the Communal forests. The work progresses more slowly in the latter than in the former, because in their case the funds have to be provided by the communes, and the money is not always available; but, as a matter of course, the most important forests were taken in hand first, and these have for the most part been completed."

The practical work that has to be carried out in order to obtain **the requisite data for the Formation of a Working Plan** consists in the following:—

1. **A survey** of the woodland portions of the estate. This should always be made by means of the chain and the theodolite, as it is more accurate, especially when the work has to be carried out in forests on hilly tracts. When large areas are being dealt with, a trigonometrical net will, of course, have to be formed, the main points of which can easily be fixed accurately in connection with one or other of the trigonometrical stations of the Ordnance Survey.

According to Burckhardt (*Hülfstafeln für Forsttaxatoren*, 1861, p. 243), a trigonometrical net is to be recommended whenever the area under survey amounts to 2000 acres on fairly level ground; whereas on difficult hilly land a net should be projected for all areas over 700 acres in extent.

Any old plans that are available should be proved by test-lines before being accepted as correct and suitable for forming the basis in the determination of the actual area of the growing crops of timber. When contour lines are shown on the map, they are of great subsequent utility for projecting lines of road, estimating gradients, &c.

Whilst the preliminary survey work is being carried out, the areas of the different crops should first of all be entered briefly in a rough register of the following description:—

Locality.		Acreage under timber-crops.	Acreage unwooded.	Total acres.	Brief description of the areas and the timber-crops.
Name.	No. of Compartment.				

In the case of high-forest crops, when the survey has been completed, and all the different areas showing variations in the nature of the crop have been specified on one copy of the map, a subdivision of the total area into **Blocks** or **Districts** and **Compartments** or **Divisions** must take place in as convenient a form as is possible for general administrative purposes. The **Blocks** or **Districts** (which are indicated by Roman numerals, I., II., III., &c., on reduced maps carried by the foresters) are aggregations of Compartments or Divisions; whilst these latter (distinguished on the small maps by Arabic numerals, 1, 2, 3, &c.) form the **units of administration.** Each block is subjected to treatment by itself, independently of the other blocks, in the case of extensive estates. In their formation the boundary-lines should, so far as convenient, follow the natural features of the land (*e.g.*, watersheds and ridges of hills, streams, &c.), although good broad roads also make excellent boundaries. So far as possible, similar good lines (ridges, brooks, green lanes, &c.) are selected in the formation of compartments.

When the blocks and compartments are being formed, it will not usually be found that the crop within the latter will be homogeneous, *i.e.*, similar in regard to kind of trees forming the crop, age of the latter, &c.; hence **Subdivisions** (which are indicated by letters *a*, *b*, *c*, &c., on the small maps) may prove convenient and advantageous. But any differences of this nature will ultimately become obliterated when the whole forest has been worked under the provisions of the working plan for one complete period of rotation; for then each compartment will consist of a crop as nearly homogeneous with regard to species of trees, method of treatment, and age of crop, as the given soil and situation will permit of.

Should there be any great differences in the ages of the crops forming the compartments, or should they consist of kinds of trees that do not attain maturity at anything like the same date, then subdivisions must be made in the interest of those portions of the crop which only attain maturity much later than that on the rest of the area. But in the course of time, and with special consideration being given to this object in the working plan, these differences and hindrances to economical working of the forest will ultimately be removed; and with their removal the necessity for maintaining subdivisions of course disappears.

Wherever practicable, the most convenient size for compartments on hilly land will usually be found to vary from about 30 to 50 acres, although in extensive woodland areas this may range up to about 70 to 80 acres. But, on the whole, compartments that are too large are often difficult to fit conveniently into the working plan; such are therefore less advantageous from the practical point of view, although they may look desirable upon paper from a theoretical standpoint. On fairly level tracts the most convenient size of the individual compartments varies usually from 50 to 70 acres, which may be subdivided where necessary into a northern and a southern subdivision. The most suitable boundary-lines in these cases consist of roads, green lanes, paths, &c., along which transport of timber can take place from the various falls.

When these compartments, and if necessary subdivisions, have all been accurately demarcated, and the nature of the soil and of the growing crops has been thoroughly investigated, the results are entered in detail into a **Register of Areas and Crops**, which forms the first section of the **Working Plan.** The excellent form prescribed for the Hanoverian forests, before the annexation of that province by Prussia (1866), was practically as follows:—

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

With regard to the above illustrations, it need only be explained that the entries I., II., III., which refer to the fellings, mean that, as will afterwards be mentioned, the working plan is usually framed for 100 or 120 years, subdivided into periods of 20 years each, and that the actual operations of felling, planting, weeding, cleaning, thinning, &c., are only **forecast in detail for the first period.** Reference to any operations in subsequent periods are only indicated in a rough general manner by affixing the Roman numerals II., III., IV., V., and VI., in order to indicate the term at which the present crop will probably attain maturity, and fall to the axe for harvesting and utilisation.

With regard to Compartment 2 of the Windy Knowe block, the entry shows that the quality of the land is at present only V. or **inferior** (see table in chapter xiii. p. 358) for Beech, but that it may be estimated as about III. or **average** for Spruce; hence it should be well adapted for forming a mixed crop of the coniferous species of trees, as soon as the present inferior crop of Beech has been cleared during the next 20 years (Period I.).

The formation of compartments varies essentially according to the nature of the crop and the treatment accorded to it.

Thus for **Coppice**, or for **Copse**, *i.e.*, coppice under standards, the simple division of the total area into the requisite number of annual falls is sufficient. In **High-Timber Forest** the arrangement of the work for Period I., or the coming 20 years, occasionally gives a good deal to think about, especially when there is a dearth of crops that are nearly mature, and which can be utilised so as to provide annual falls of approximately equal outturn.

The second section of the working plan consists of the **Classification of the Various Crops** according to their ages, and according to the periods during which they will become mature, or are intended to be utilised.

This classification is tabulated in the manner shown on next page.

The explanation of these entries will easily be seen by comparison with the Register of Areas and Crops.

The next section of the working plan relates to the **Distribution of the Fellings.** It is arranged in the following tabular form :—

Locality.	Area		Annual fellings.					
				Clearances of mature crops.		Thinnings.		Total outturn in loads of 50 cubic ft.
	Of whole block.	Under wood.	During period.	Area.	Estimated yield in loads of 50 cubic ft.	Area.	Estimated yield in loads of 50 cubic ft.	
	Acres.	Acres.		Acres.		Acres.		
Block I.	2,015	2,000	I.	100	18,000	500	3,500	21,500

The estimates of the outturn probably obtainable from the mature crops and from thinnings are, of course, taken from average normal yield tables (as formerly described in chapter xiii., see p. 358) for the given quality of soil, modified according to the relative density of the crop. The greatest attention is naturally paid to the estimates of the final yield of the crops that fall to the axe for harvesting during Period I., *i.e.*, during the next 20 years. Wherever it may seem desirable, the periodic falls may be forecast only in area, or only as to outturn; but where convenient a statement both of acreage and of yield is preferable.

Locality.		Area under timber-crops.	Nature of soil and crop.				Classification of the crops in periods of 20 years each.												Age at time of felling.	Blank and vacant land to be planted during the following periods.		
							As to present age.						As to time of felling.									
Block.	Compartment.		Species of crop.	Quality of soil.	Density.	Age.	I.	II.	III.	IV.	V.	VI.	I.	II.	III.	IV.	V.	VI.		I.	II.	III.
		Acres.					Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Years.	Acres.	Acres.	Acres.
I. Windy Knowe	1	40	Oak and Beech .	II.	0.9	110	...	...	...	...	...	40	40	...	...	...	...	...	120	...	...	...
"	2	43	Beech . . .	V.	0.7	80	...	...	...	...	43	...	43	...	...	..	...	...	85	...	...	...
"	3	25	Mixed Hardwoods	III.	1.0	46	...	...	...	25	...	...	...	...	25	...	...	...	120	...	...	...
"	3a	20	Oak and Beech .	II.	0.8	100	...	...	...	...	...	20	...	20	...	...	...	...	130	...	...	...

Two subdivisions of this section are attached to the above table exhibiting the Distribution of the Fellings, in order to specify in a more detailed manner the areas to be operated on. These sub-sectional tables are in the following forms:—

Details concerning fellings in mature crops for the first half of Period I.—*i.e.*, from 1894 to 1903.													
Locality.		Nature of soil and crop.				Extent and results of operations.							
							Yield or outturn.						
Block.	Compartment.	Species of crop.	Quality of soil and situation.	Density of crop.	Age of crop.	Area of timber crops felled.	Oak.	Other Hardwoods.	Softwoods.	Pine.	Larch.	Other Conifers.	Total loads of 50 cubic feet.
							In loads of 50 cubic ft.						
					Years.	Acres.							

Details concerning thinnings during the first half of Period I.—*i.e.*, from 1894 to 1903.											
Locality.		Total area.	Nature of soil and crop.				Area to be thinned during the next 10 years.		Estimated yield of thinnings for Period I.		
									Per acre.	Total.	
Block.	Compartment.		Species of crop.	Quality of soil and situation.	Density of crop.	Age of crop.	To be thinned once.	To be thinned twice.	Loads of 50 cubic ft.		Ruling species of tree in the crops thinned.
		Acres.				Years.					

In the above cases the usual classification adopted in Germany, viz., six periods of 20 years each, has been referred to. But the length of time for which the working plan should be forecast must be determined mainly by the period of rotation of the ruling crops. Thus for the North of Scotland, if the crops consist mainly of Pine, Larch, and other Conifers, worked with a rotation of 60 to 80 years, then the working plan would be most conveniently framed for six periods of 10 years, or four periods of 20 years. But, in any case, as may be noted in the two last tables giving details concerning fellings and thinnings, if Period I. embrace 20 years, the details are only given for the first decade. A revision requires to be made every 10 years, and that is the proper time for laying down detailed instructions regarding the conduct of operations during the ensuing 10 years. If these were particularised too far in advance, they would be so apt to be disturbed by external influences (wind, fire, insects, very favourable market opportunities, &c.) as to have little practical value. Hence, *for* 10 *years the working plan should be followed as closely as circumstances will permit;* but beyond that time it

serves merely as a general forecast of what might and should be done, if no unusual and unforeseen disturbances arise.

In order to expedite these **Revisions of the Working Plan** held every 10 years, an **Annual Register of Operations** should be kept in the following form :—

Annual Register of Operations.									
Estimated annual yield . .				Fellings in mature crops		.. acres.		.. loads of 50 cubic ft.	
				Thinnings . . .		.. acres.		.. loads of 50 cubic ft.	
Year.	Locality.		Area in Acres.	Estimated yield.	Actual yield.	In relation to the estimated yield, the actual outturn was			
	Block.	Compartment.		In loads of 50 cubic ft.		Above the former	Below the former	Total.	
						+	−	Excess +	Deficit −
$189\frac{4}{5}$									
$189\frac{5}{6}$									

When these books are kept correctly and regularly, the work of revision is neither difficult nor costly. It is, of course, almost essential that the whole of the crops to be felled during the coming 10 years should be revised in order to take note of any improvement, or the reverse, since the last revision, as this may affect the estimated outturn. And to whatever extent changes may seem desirable or necessary in the working plan, consequent on variations as to the state of the growing crops, effect must of course be given.

Such a system may seem unwieldy and unnecessarily elaborate for the conditions obtaining on most of the woodland estates in Britain. But, in any case, some sort of working plan, whether simple or studiously methodical, is absolutely essential in order that the productive capacity of the soil may be both utilised and safeguarded to the greatest possible extent, and that, in fact, uneconomical **Arboriculture** may gradually give place to scientific **Sylviculture** in which the leading object is the best returns *in perpetuo* that can possibly be obtained from the capital represented by the soil plus the growing stock of timber crops.

CHAPTER XV.

SYSTEM OF BOOK-KEEPING ON WOODLAND ESTATES.

System of Book-keeping adapted to Forest Operations.—To be able to keep correct and satisfactory accounts of all transactions, whether with respect to income or expenditure, is a great recommendation to the person who professes to manage any business; and this equally holds good with regard to a person who manages woods, as well as in any other profession. A forester who is not able to keep correct account-books in reference to all the transactions that may pass under his hands would really be little better than a mere woodman or overseer.

In the present state of Forestry in Britain, there are comparatively few foresters who are good accountants, and who can show their employers, at any time they may ask for detailed information, the real state of income or expenditure in any given branch of the charge under them. Knowing, therefore, that foresters would be much benefited by having such a system of book-keeping specially adapted to their use as may be considered simple and comprehensive, the author here proposes to draw up forms specially for their requirements, which he thinks will be found simple enough to be easily understood.

The very first account which a forester should make out on entering on the duties of a new year (at whatever time of the year this may be—and this, of course, will always depend on the time that the proprietor makes up his yearly accounts) is a sort of Budget or **Estimate of Revenue and Expenditure**, setting forth the particulars of income and expenditure for the coming year. Without such an estimate to guide both the forester himself and his employer, both would be, with regard to the works generally, similarly circumstanced to a mariner at sea without a chart. Such a statement is, in short, the groundwork of good management to a forester in all his operations for the coming year; and, at the same time, it is also most satisfactory for the proprietor, inasmuch as it enables him to understand, at the commencement of the year, what the forester intends to draw for him as income from his woods, as well as what he intends to expend on the various works proposed to be performed. Such a

statement should be made as simply and clearly as possible; elaboration of detail is only apt to make it confusing without being otherwise of benefit.

In the case of very large forest estates, as, for instance, in the State forests of France, Germany, India, &c., all work is regulated by the provisions of such **Budget Estimates**. For the submission, revision, and carrying out of the estimates, detailed instructions are issued in the Forest Code or Departmental Rules. For smaller landowners such formal methods have no object.

ESTIMATE OF THE PROBABLE INCOME FROM, AND EXPENDITURE ON, the WOODLANDS on the ESTATE OF LYNMORE, for the year from 1st May 1894 to 30th April 1895 :—

A.—INCOME.

		Amount.	Total.
1. **Sales by Public Auction:**			
From sales of 10,000 Larch trees on the Hill of Bands, say at 10s. per tree		£5,000 0 0	
From sales of 12,000 Scots Pine trees, in Plantation of Gorry, at 6s. per tree . .		3,600 0 0	
From sales of Oak timber from Adam's Wood, say 5000 ft. at 2s. 6d. per ft. . . .		625 0 0	
			£9,225 0 0
Remark.—In making the above valuation, the price of Larch is reckoned at 1s. per cubic ft. and Scots Pine at 8d. per cubic ft.			
2. **Sales by Private Contract:**			
From sales of Pine and Larch thinnings from the Plantations of Burnside, Woodhead, Clury, Laggan, and Lait		£700 0 0	
From thinnings of Oak from Rettie, Sluggan, and Eden Plantations		400 0 0	
From thinnings of mixed Hardwoods from Damhead and Strawn Plantations . .		200 0 0	
From 50 tons of bark from old Oak timber, say at £5 per ton		250 0 0	
From bark from thinnings of young Oak plantations, say 80 tons, at £7 per ton .		560 0 0	
			2,110 0 0
3. **Nursery Stock to go out next Autumn and Spring:**			
40,000 Oak, at 30s. per 1000 .	£60 0 0		
16,000 Ash, at 25s. ,, .	20 0 0		
4,000 Elm, at 25s. ,, .	5 0 0		
200,000 Larch, at 10s. ,, .	100 0 0		
400,000 Scots Pine, at 6s. ,, .	120 0 0		
6,000 Spruce, at 12s. ,, .	3 12 0		
666,000		308 12 0	
10,000 Thorns, at 15s. per 1000 . . .		7 10 0	
			316 2 0
4. **Rents of three Lodges**		18 0 0	
			18 0 0
5. **Rents of three Sawmills**		110 0 0	
			110 0 0
Total estimated income . . .			£11,779 2 0

B.—EXPENDITURE.

	Amount.	Total.
1. Salaries and Allowances:		
Forester	£300 0 0	
Horse-keep	30 0 0	
Assistant	100 0 0	
Horse-keep	30 0 0	
Woodmen in charge of enclosures, four at £40 each	160 0 0	
Clerk to Forester	60 0 0	
		£680 0 0
2. Fencing:		
Braidwood Hill to enclose for planting, say 3500 yards of wire-fence, at 8d. per yard	116 13 4	
Thortown Bridge to enclose for planting, say 4000 yards of stone wall, 5 ft. high, at 2s. per yard	400 0 0	
General repair of fences on enclosures	150 0 0	
Repairs of gates on enclosures	20 0 0	
		686 13 4
3. Draining:		
Braidwood Hill, 30 acres of, say at £3 per acre	90 0 0	
Thortown Bridge, 45 acres of, say at £3, 5s. per acre	146 5 0	
		236 5 0
4. Planting:		
Braidwood Hill and Thortown Bridge enclosures, 666,000 plants, as per statement under heading of Income, *Nursery Stock to go out*	308 12 0	
Expense of planting	99 18 0	
60,000 pits for Hardwoods, at 1s. per 100	30 0 0	
Carriage of plants	10 0 0	
		448 10 0
5. Lodges:		
Repairs of	70 0 0	
		70 0 0
6. Water-Runs:		
Repairs of sides of	110 0 0	
		110 0 0
7. Sawmill Dams:		
Repairs of	30 0 0	
		30 0 0
8. Roads, Rides, and Walks:		
New road from Saltown Bridge to Westergates, say 2300 yards, at 1s. 6d. per yard	172 10 0	
Repairs of roads generally	30 0 0	
Repairs of rides	18 0 0	
Repairs of walks, and cleaning	40 0 0	
		260 10 0
Carry forward		£2,521 18 4

	Amount.	Total.
Brought forward . .		£2,521 18 4
9. Hedging:		
On side of proposed new road betwixt Saltown Bridge and Westergates, preparing 1,666 yards of bed for Thorn plants, at 6d. per yard	£41 13 0	
10,000 plants, at 15s. per 1000 . . .	7 10 0	
Planting	2 10 0	
Carriage of plants	0 5 0	
Cleaning of hedges generally . . .	60 0 0	
Switching of hedges " . . .	50 0 0	
		161 18 0
10. Felling and Preparing Oak Timber for Sale:		
Say 100 trees in Adam's Wood, at 2s. 6d. per tree	12 10 0	
		12 10 0
11. Stripping and Curing Oak Bark:		
Say 130 tons, at £2, 10s. per ton . . .	325 0 0	
		325 0 0
12. Thinning:		
Pine and Larch plantations, as named in estimate of income	235 0 0	
Oak and mixed Hardwood plantations, as named in estimate of income . . .	60 0 0	
		295 0 0
13. Clearing and Burning Rubbish:		
From cleared land, Heathfield enclosure, say	30 0 0	
		30 0 0
14. Pruning:		
Young Oak plantation at Rymore, say .	8 0 0	
		8 0 0
15. Nursery:		
(*a.*) *Nursery Stock and Plants required for Next Year's Stock—*		
20,000 Oak, 1-yr. seedling, at 7s. 6d. per 1000	7 10 0	
10,000 Ash, 2-yr. do., at 7s. per 1000 . .	3 10 0	
3,000 Elm, 2-yr. do., at 7s. 6d. per 1000 .	1 2 6	
150,000 Larch, 1-yr. do., at £12 per 100,000	18 0 0	
300,000 S. Pine, 1-yr. do., at £17 per 100,000	51 0 0	
2,000 Silver Fir, 2-yr. do., at 7s. 6d. per 1000	0 15 0	
5,000 Spruce, 2-yr. do., at 3s. per 1000 .	0 15 0	
2,000 Sycamore, 2-yr. do., at 10s. per 1000	1 0 0	
500 Lime-tree, at 15s. per 100 . .	3 15 0	
500 new Coniferæ, of sorts, at 1s. each .	25 0 0	
8,000 Thorns, at 15s. per 1000 . . .	6 0 0	
501,000		118 7 6
(*b.*) *Nursery Labour:—*		
Laying 501,000 plants, at 1s. per 1000. .	25 1 0	
Cleaning	8 0 0	
Lifting.	6 0 0	
Digging	7 0 0	
Manuring with compost-earth and leaf-mould	5 0 0	
		51 1 0
Carry forward . .		£3,523 14 10

	Amount.	Total.
Brought forward . .		£3,523 14 10
16. **Rates and Taxes**	£80 0 0	80 0 0
17. **Sundries**:		
Travelling expenses of Forester and assistant	25 0 0	
Stationery	8 0 0	
Legal expenses and criminal prosecutions .	35 0 0	
Carpenter work	4 0 0	
Smithy work	10 0 0	
Ironmongery	8 0 0	
Keep of forest work-horse	25 0 0	
Wages of carter	30 0 0	
Repairs of harness (or saddlery) . . .	3 0 0	
Advertisements of timber sales . . .	15 0 0	
Sale dinners	10 0 0	
Printing catalogues and bills . . .	5 0 0	
Auctioneer's charges	10 0 0	
		188 0 0
Total estimated expenditure . .		£3,791 14 10

This statement should be docketed outside with an abstract of the income and expenditure in the following form:—

Abstract.	
Estimated income	£11,779 2 0
Estimated expenditure	3,791 14 10
Estimated nett income . .	£7,987 7 2

In the case of very large woodland estates, like State forests, the financial statements annually submitted are divisible into three sections as follows:—

Actuals for the past year.	Revised estimate for the present year.	Budget estimate for the coming year.
1893–1894	1894–1895	1895–1896

All the items of revenue and expenditure are thus exhibited side by side; and where considerable differences exist between columns 3 and 2, or between 2 and 1, an opportunity is given of explaining the variations to the satisfaction of the superiors. Where this system can be introduced on large estates, it is of very decided advantage; for the management can then see nearly two clear years ahead, and thus better arrangements can be made for the carrying out of work. It is more satisfactory for management, and forms an easily intelligible and unmistakable record, which can exhibit to the proprietor at a glance whether the nett revenue derivable from the woodland portions of his estates is increasing or decreasing.

The foregoing statement is an example of the way in which, at the beginning of every year, the author was in the habit of making

up an estimate of the income expected to be derived from the produce of such forests and plantations as he had the management of, and the expenditure to be laid out on them. A copy of the estimates was registered in a book kept specially for the purpose, and another was given to his employer, who, after scrutinising the whole statement carefully, either approved of the whole or of a part merely, as seemed to him most desirable. After being investigated and sanctioned, the works detailed are considered as settled and decided upon for the season, and are afterwards performed by degrees, according to the season and nature of the work. It must, of course, always be understood that the several works set forth for any given year are to be entered upon and duly completed before the end of the year, when the money-credit lapses.

Although the statement above given embraces somewhat extensive sales of produce, as well as large works to be performed, still the model is equally applicable to estimates of all dimensions, whether with regard to estates on which there are only 300 acres of woods, or from 20,000 to 100,000 acres, or more. The only practical difference is that the sums will be large or small according to the extent of woodlands to be operated on.

In drawing up such a statement, however, the forester should be very careful to make correct estimates both with regard to the income and expenditure. If they be not correct, the proof will undoubtedly tell against him at the end of the year. An opportunity can, of course, always be taken of explaining deviations from the forecast, such as are often liable to occur; but when the estimates are habitually incorrect, the employer will soon be able to form an opinion as to whether the forester is thoroughly qualified for his business, or the contrary.

To avoid such an unpleasant state of things as has been hinted at above with reference to incorrectness and incompetency in the forester, he should take ample time to calculate the value of the produce he intends to remove from any and every plantation he proposes to operate on during the year, and also that of the different works he thinks it necessary to have performed. In short, in making up his statement, he should (in a brief but concise manner) enter in it every item of income and expenditure he anticipates for the year. Whether this may amount to £100 or £20,000 depends entirely on the character of the establishment and the extent of the operations; but, in either case, the principle upon which the estimate is drawn up for guidance remains the same.

Even under the very best system of management, deviations from the forecast are at times unavoidable. The market for any particular kind of produce may fall suddenly, or many sorts of contingencies may happen that

are quite beyond the control of the head-forester, no matter how well-qualified and diligent he may be. For example, the great north-east storm of the 17th November 1893 (Scotland) must have upset the estimates on many woodland estates directly affected by the windfall; whilst at the same time, by throwing large quantities of timber upon the local markets, it can hardly fail to influence the revenue derivable during the current year from other undamaged woods in the immediate vicinity of the windfall areas.

On the supposition, then, that such an estimate has been formed for the year, the next step in the system of book-keeping which the author proposes to lay before the reader is the keeping of the **Daily Labour Book** (pp. 440–441). This is simply a detailed statement, in a tabular form, of what the workmen are employed at on each day, together with some other particulars, which will be clearly understood from the following specimen sheets, taken from one of the author's own books, kept for the like purpose. These specimen sheets embrace the particulars of the labourers' work for one month.

At the close of each month an **Abstract** in the following form should be made of the amount expended on daily labour:—

STATEMENT *of Daily Labour for the Month.*

	£	s.	d.
First week	5	3	9
Second week	6	9	0
Third week	5	13	9
Fourth week	6	8	0
Total . .	23	14	6

It will also be found exceedingly useful, and will save a great deal of time and trouble subsequently, if the expenditure is allotted month by month to the different works executed, *e.g.*—

Felling in Adam's Wood.	Cleaning hedges.
Thinning in Bankhead.	Pruning in Rymore, &c.

The cost of all such operations must be calculated later on; hence it is strongly advisable to have them made out month by month, so as, along with other advantages, to know that the amount sanctioned for each individual operation is not being exceeded, or to see if more can be done than was originally intended with the sum at disposal.

The foregoing system of keeping the particulars in regard to the labourers' time is so very clear and simple, that little or no explanation seems necessary concerning it. Still, for the benefit of young and inexperienced men in the profession, the author would advert a little to it, and give such explanation as he thinks most likely to be useful.

It will be observed from the heading of this copy of a daily-labour book, that the month begins on Monday the 1st May, 18—, which

DAILY-LABOUR ROLL.

STATEMENT OF WORKMEN EMPLOYED IN THE WOODS ON THE ESTATE OF LYNMORE from 1st to 13th May 18—.

Day of the Week.	Monday.	Days.	Hours.	Tuesday.	Days.	Hours.	Wednesday.	Days.	Hours.	Thursday.	Days.	Hours.	Friday.	Days.	Hours.	Saturday.	Days.	Hours.	Total No. of Days.	Rate per Day.	Amount.
Day of the Month.	1st May.			2nd.			3rd.			4th.			5th.			6th.					
																				s. d.	£ s. d.
A. M'Gregor	Felling Oak Timber, Adam's Wood.	1	0	Felling Oak Timber, Adam's Wood.	1	0	Felling Oak Timber, Adam's Wood.	1	0	Felling Oak Timber, Adam's Wood.	1	0	Felling Oak Timber, Adam's Wood.	0	5	Thinning Bank-head Oak Plantation.	1	0	5.5	2 6	0 13 9
J. Grant .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	5	... ...	1	0	5.5	2 0	0 11 0
D. Fraser .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	Absent.	0	0	... ...	1	0	5.0	...	0 10 0
J. M'Donald	... ...	1	0	... ...	1	0	... ...	1	0	.. ...	1	0	... ...	0	0	... ...	1	0	5.0	...	0 10 0
W. Scott .	... ...	0	5	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	... ...	1	0	4.5	...	0 9 0
D. Ross . .	... ...	0	5	Absent.	0	0	... ...	1	0	... ...	1	0	... ...	0	0	... ...	1	0	3.5	...	0 7 0
W. Calder .	... ...	0	5	... ...	0	0	... ...	1	0	... ...	1	0	... ...	0	0	... ...	1	0	3.5	...	0 7 0
A. Robertson	... ...	0	5	Felling Oak Timber.	1	0	... ...	1	0	... ...	1	0	... ...	0	0	... ...	1	0	4.5	...	0 9 0
J. Watson .	... ...	1	0	.. ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	... ...	1	0	5.0	...	0 10 0
J. M'Cook .	... ...	1	0	... ...	1	0	... ...	0	5	... ...	1	0	... ...	0	0	... ...	1	0	4.5	...	0 9 0
H. Cameron	... ...	0	5	... ...	1	0	... ...	1	0	... ...	0	5	.. ...	0	0	... ...	1	0	4.0	...	0 8 0
																					5 3 9
Day of the Month.	8th.			9th.			10th.			11th.			12th.			13th.					
A. M'Gregor	Thinning Bank-head Oak Plantation.	1	0	Thinning Bank-head Oak Plantation.	1	0	Cleaning Hedges, North Park.	1	0	Repairing Fences on South District of Enclosures.	1	0	Repairing Fences on South District of Enclosures.	1	0	South District Enclosure, Scouring Drains.	1	0	6.0	2 6	0 15 0
J. Grant .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	5	5.5	2 0	0 11 0
J. M'Donald	... ...	1	0	Absent.	0	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	5	4.5	...	0 9 0
W. Scott .	... ...	1	0	Thinning Bank-head Oak Plantation.	1	0	... ...	1	0	... ...	1	0	... ...	0	5	... ...	1	0	5.5	...	0 11 0
A. Robertson	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	6.0	...	0 12 0
D. Ross .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	5	... ...	1	0	... ...	1	0	5.5	...	0 11 0
W. Calder .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	Absent.	0	0	5.0	...	0 10 0
J. Watson .	... ...	1	0	.. ...	1	0	... ...	1	0	... ...	0	5	... ...	1	0	... ...	0	0	4.5	...	0 9 0
H. Cameron	... ...	1	0	... ...	1	0	.. ...	1	0	... ...	0	5	... ...	1	0	... ...	0	0	4.5	...	0 9 0
J. M'Cook .	... ...	1	0	... ..	1	0	.. ...	1	0	... ...	1	0	... ...	1	0	Scouring Drains.	1	0	6.0	...	0 12 0
D. Fraser .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	6.0	...	0 12 0
T. Low . .	Absent.	0	0	Absent.	0	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	4.0	...	0 8 0
																					6 9 0

DAILY-LABOUR ROLL—(*continued*).

STATEMENT OF WORKMEN EMPLOYED IN THE WOODS ON THE ESTATE OF LYNMORE, from 15th to 27th May 18—.

Day of the Week.	Monday.	Days.	Hours.	Tuesday.	Days.	Hours.	Wednesday.	Days.	Hours.	Thursday.	Days.	Hours.	Friday.	Days.	Hours.	Saturday.	Days.	Hours.	Total No. of Days.	Rate per Day.	Amount.
Day of the Month.	15th.			16th.			17th.			18th.			19th.			20th.				s. d.	£ s. d.
A. M'Gregor	Thinning Sluggan Plantation.	1	0	Home Policy, Cleaning Walks.	1	0	Home Policy, Cleaning Walks.	1	0	Pruning Oaks in Rymore Plantation	1	0	Pruning Oaks in Rymore Plantation	1	0	Pruning Oaks in Rymore Plantation	0	5	5.5	2 6	0 13 9
J. Grant .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	Absent.	0	5	5.5	2 0	0 11 0
D. Ross . .	... ...	0	5	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	4.5	...	0 9 0
W. Scott .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	5.0	...	0 10 0
D. Fraser .	Absent.	0	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	4.0	...	0 8 0
J. M'Donald	... ...	0	0	... ...	1	0	... ...	1	0	Absent.	0	0	... ...	1	0	... ...	0	0	3.0	...	0 6 0
W. Calder .	Thinning Sluggan Plantation.	1	0	... ...	1	0	... ...	1	0	... ...	0	0	... ...	1	0	... ...	0	0	4.0	...	0 8 0
J. Watson .	... ...	1	0	. . ...	1	0	... ...	1	0	Pruning Oaks in Rymore Plantation	1	0	... ...	1	0	... ...	0	0	5.0	...	0 10 0
A. Robertson	... ...	1	0	... ...	0	5	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	4.5	...	0 9 0
J. M'Cook .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	5.0	...	0 10 0
H. Cameron	... ...	0	5	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	4.5	...	0 9 0
T. Low . .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	5.0	...	0 10 0
																					5 13 9
Day of the Month.	22nd.			23rd.			24th.			25th.			26th.			27th.					
A. M'Gregor	Thinning in Eden Plantation.	1	0	Thinning in Eden Plantation.	1	0	Thinning in Eden Plantation.	1	0	Cleaning Nursery.	1	0	Lotting Oak Timber for Sale, Adam's Wood.	1	0	Lotting Oak Timber for Sale, Adam's Wood.	1	0	6.0	2 6	0 15 0
J. Grant .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	6.0	2 0	0 12 0
D. Ross . .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	6.0	...	0 12 0
W. Scott .	... ...	1	0	... ...	1	0	.. ...	0	5	... ...	1	0	... ...	1	0	... ...	1	0	5.5	...	0 11 0
D. Fraser .	... ...	1	0	... ...	1	0	... ...	0	5	... ...	1	0	Absent.	0	0	... ...	1	0	4.5	...	0 9 0
T. Low . .	... ...	1	0	... ...	1	0	... ...	0	5	... ...	1	0	... ...	0	0	... ...	1	0	4.5	...	0 9 0
J. M'Cook .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	... ...	1	0	5.0	...	0 10 0
H. Cameron	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	... ...	1	0	5.0	...	0 10 0
A. Robertson	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	Lotting Oak Timber, Adam's Wood.	1	0	... ...	1	0	6.0	...	0 12 0
J. Watson .	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	Absent.	0	0	5.0	...	0 10 0
W. Calder .	... ...	1	0	... ...	0	5	... ...	0	5	... ...	1	0	... ...	1	0	.. ...	0	0	4.0	...	0 8 0
J. M'Donald	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	1	0	... ...	0	0	5.0	...	0 10 0
																					6 8 0

is supposed to be the first month of the business or financial year on the estate of Lynmore; but it must be clearly understood that no precise month need be taken as the beginning of the year in making out such a statement, as this may be any month, according to the usual business year maintained on the property with respect to the winding-up and balancing of financial affairs.

Under the above heading the pages are divided, from bottom to top, into seven main columns—apart from the money columns, &c. The first, on the left-hand side, is for the names of the men employed, and the other six are for the working days of the week; whilst there are small intermediate columns for the days and hours that each man is employed. After the days of the week, there is a column for the total number of days each man is employed during the week; next comes a column for the rate of wages he receives per day; and lastly comes one in the usual manner of money columns, in which the sum each man is to receive for that week is entered.

If there are not many men employed, one folio of the book, or two opposite pages, will hold the transactions of two weeks; but if many hands are employed, it will take all the space of the two pages to do justice to the description of the work; and of course this must always be regulated according to the nature of the establishment.

With regard to the horizontal lines which intersect the upright columns from side to side of the page, the first requirement is, of course, to make spaces for the days of the week, which are stated each in its compartment, and at the head of its own special column. Immediately under, another horizontal line runs from side to side, making compartments at the tops of the several columns for the days of the months, so that the days of the week and the days of the month are made to correspond to each other. If it be considered desirable, two lines can next be drawn, so as to form compartments for registering the state of the weather and the temperature registered by the thermometer at a certain constant time during each consecutive day. In the specimen pages these two compartments have not been exhibited, although they may frequently prove useful as well as interesting.

But if these two series of spaces be opened, then it will be strongly advisable to open a line for *rainfall* also, as this is at least equally important from a forest-meteorological point of view.

The author would also carry his remarks a little further, and show how the men's time is registered in this book; and in order to do this, he will describe the entries made in reference to one or two of the hands employed. A. M'Gregor, the first man named on the list

for the week ending on Saturday the 6th of May, is, on Monday the 1st May, stated to have been felling Oak timber in Adam's Wood, and on the same day the other ten men were employed on similar work in the same wood. Of course, where the men are employed on different jobs, the work that each man is engaged in must be carefully described under the date and in the compartment for the purpose. But no remarks seem called for on this point, as the columns themselves are so clear that they can hardly be misunderstood.

It will be observed that in the statement for the week ending Saturday the 13th May, the same man, A. M'Gregor, is registered on the 11th and the following day as repairing fences on the south district of enclosures, and that on the same days all the other men were employed on similar work along with him; but that on Saturday, while William Calder, James Watson, and H. Cameron are marked as absent, all the others were engaged in scouring drains in south district enclosures. All this, he thinks, is clear enough to be understood by any forester; but there are a few points yet to be remarked on, to which the author would call particular attention.

The particulars of each day's operations, so far as the labouring men are concerned, should be marked down in the evening, when the forester returns home, and should on no account be left till another day. If this precaution be neglected, then it is probable that new works will distract his mind and prevent his entering the transactions of the previous day in a perfectly correct manner.

The forester must always be careful, in keeping the **Daily Labour Book**, not only to give the details of the various operations that the different men may have been engaged in during each day, but also to note very particularly the district or particular plantation in which the work has been performed. Without doing this, he cannot possibly fill up satisfactorily the next book to be described (the **Pay-Sheet**), neither can he detail correctly, at the end of the financial year, when the different operations have all been completed, in what plantation or in what part of the estate the various specific items of the different works executed have been done. This point should, therefore, be kept specially in view by the forester. To the inexperienced book-keeper in forestry this may seem a matter of little consequence; but to the man who has had any considerable experience in rendering correct accounts to his employer, it is found of vast importance, as will more particularly appear when the author proceeds with his proposed system of forest accounts.

It is also necessary that the forester should, on the evening of each date, note in its proper place the general state of the weather, as well as the degree of the thermometer, at a given time of the day. The author suggests 9 A.M. as a convenient time; but a register ought

to be taken at the height of the diurnal temperature, which is usually between two and three o'clock in the afternoon.

The great drawback to this is that the forester cannot both be supervising his own men properly and looking at the thermometer at 9 A.M. and 2.30 P.M. Where a series of meteorological observations is aimed at, it will be far better to adopt the system of *maxima and minima readings*, as these can be read off by the forester himself from the thermometer each evening without interfering in the slightest degree with his other duties, or involving any necessity for another person's assistance.

At the same time, if any effort is to be made at recording meteorological data, then it is highly desirable that the use of a rain-gauge should be added, so as to collect information concerning the total amount of the aqueous precipitations (rain, snow, dew, &c.).

Men employed in contract or piece work should not, of course, have their time noted in the book under notice, but only day-labourers, as the statement in respect to contract-work will be accounted for elsewhere.

The daily-labour book should be made large enough to last one year, so that reference can be made to each book for the labour of the year it represents.

The next book in the order of the system is the Pay-List of Daily-Labour and Piece-Work. (See opposite page.)

The specimen-sheet given of the book called the **Pay-Sheet or Account of Daily Labour and of Piece-Work** contains the entire labour transactions of the month, or four weeks, as particularised in the specimen given of the daily-labour book itself, together with the contract or piece-work performed and paid for during the same period. The *daily-labour* part of the sheet contains, in a condensed form, all the different works every man has been employed on during the month, and as particularised in the daily-labour book; while the *piece-work* part of it exhibits, also in a condensed form, but with all the particulars necessary for the proper description regarding the payment, the contract-work that has been performed and falls to be accounted for during the month.

By way of example, the time of the man Alexander M'Gregor may be considered, as he is first named on the list, and his number is therefore 1. Under column No. 1 he is set down as having been 4 days 5 hours employed on felling Oak timber in Adam's Wood; under the 2nd, as having been 3 days engaged in thinning Bankhead Plantation; under the 3rd, 1 day employed cleaning hedges on North Park; under the 4th, 2 days in the repairing of fences on the enclosures of the south district—and so on, with the days set down opposite to his name. On summing up the whole of this man's time, it will be found to be 23 days in all; this is, therefore, the number set down for him to receive payment for under column 13, which

OF LYNMORE during the Month of May 18—.

Nos.	Names.	10. Nursery, Cleaning. Amount	11. Adam's Wood, Lotting Timber. Days	Amount	12. Days	Amount	13. Total No. of Days.	14. Rate per Day.	15. Total Amount.	16. We, the undersigned, acknowledge to have received from —— —— the sums set opposite our names respectively, as payment of our wages for the time herein set forth.
		£ s. d.		£ s. d.				s. d.	£ s. d.	(Signed)
1.	A. M'Gregor	0 2 6	2	0 5 0			23.0	2 6	2 17 6	Stamp A. M'Gregor.
2.	J. Grant .	0 2 0	2	0 4 0			22.½	2 0	2 5 0	Stamp J. Grant.
3.	D. Fraser .	0 2 0	1	0 2 0			19.½	2 0	1 19 0	D. Fraser.
4.	J. M'Donald	0 2 0	1	0 2 0			17.½	2 0	1 15 0	J. M'Donald.
5.	W. Scott .	0 2 0	2	0 4 0			20.½	2 0	2 1 0	Stamp W. Scott.
6.	D. Ross .	0 2 0	2	0 4 0			19.½	2 0	1 19 0	D. Ross.
7.	W. Calder	0 2 0	1	0 2 0			16.½	2 0	1 13 0	W. Calder.
8.	A. Robertson	0 2 0	2	0 4 0			21.0	2 0	2 2 0	Stamp A. Robertson.
9.	J. Watson	0 2 0	1	0 2 0			19.½	2 0	1 19 0	J. Watson.
10.	J. M'Cook	0 2 0	1	0 2 0			20.½	2 0	2 1 0	Stamp J. M'Cook.
11.	H. Cameron	0 2 0	1	0 2 0			18.0	2 0	1 16 0	H. Cameron.
12.	T. Low .	0 2 0	1	0 2 0			13.½	2 0	1 7 0	T. Low.
		1 4 6		1 15 0					23 14 6	
							Total .		£23 14 6	

during the Month of May 18—.

Nos.		Quantity.	Rate per Yard.	Amount paid for Piece-work.	Total Amount.	We, the undersigned, acknowledge to have received from —— —— the sums set opposite our names respectively, in payment of the piece-work therein mentioned.
			s. d.	£ s. d.		(Signed)
1.	James Smith	2000 yards.	0 2	16 13 4		Stamp J. Smith.
2.	Angus Came	000 ,,	0 8	33 6 8		Stamp A. Cameron.
3.	John M'Gre	200 ,,	2 0	120 0 0		Stamp J. M'Gregor.
		Amount for piece-work .		170 0 0	170 0 0	
				Total .	£193 14 6	

* Detail and should have the amounts specified fully in writing as well as in figures.

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contains the total number of days each man has been employed during the 4 weeks. Under column 14 it will next appear, in respect to this hand, that his rate of wages is 2s. 6d. per day; consequently his 23 days at this rate amount to £2, 17s. 6d., which is set down in column 15; and on his receiving this pay, he acknowledges it by signing his name across a receipt stamp under the 16th column; and so on with all the other men whose names follow on the sheet. Each man has to sign his name across a penny stamp when the amount to be received by him is £2 and upwards.

By examining Alexander M'Gregor's time, as stated in the daily-labour book, it will be found that it exactly corresponds with the number of days set down for him in the pay-list. This, of course, ought to be the case with respect to all the men's names set down in these statements. If the one statement does not correspond with the other in this respect, it is an indication that there is an error somewhere, which should of course be checked.

The great advantage of this mode of keeping men's time is, that it forms a complete account of all work that they are employed on, in the least possible space; and yet it is as clear and to the point as if volumes were written in regard to it. It is the system which has been found the most convenient by the author. It is now used on many estates, and is found to answer the purpose admirably, as it forms a complete receipt for all day-labourers' wages.

The great advantage connected with this mode of keeping the pay-list for the workmen is that it exhibits, at the end of every month, the exact expenditure which has been incurred on each particular branch of work. For example, it will at once be seen that £4, 1s. 3d. has been the amount expended under column No. 1 for felling Oak timber in Adam's Wood; that £3, 5s. 6d. under column No. 2 represents the cost of thinning Bankhead Plantation; and so on, with the sums set down under each of the headings. Seeing that each of the headings of the columns is filled up every month, as the different works may require, it therefore follows that these sheets, at the end of the year, form a complete history of the workmen's time. This is of vast importance in the keeping of correct accounts on all such matters, and in making up the actual amount of expenditure at the end of the year.

It will be observed that the statement of daily-labour for the four weeks amounts to £23, 14s. 6d. in all, and that this corresponds with the sum brought out as the result of the expenditure in the pay-list. This point should, of course, receive particular attention. If any error occur, and the accounts do not correspond, it might lead to a great amount of labour and waste of time at the end of the year.

A few remarks still remain to be made with respect to that part of the pay-list which sets forth the contract or piece work performed during the month, and which is entered on the same page or sheet with the daily-labour. Though not necessary, yet it is desirable that both should be entered on one sheet, in order to bring out the whole as one account at the end of the month.

Before entering into any bargain or contract for the performance of such piece-work, it is best to have specifications drawn up on stamped paper, which duly set forth all particulars in regard to the work in question. These specifications are of course signed by the contracting parties. When this has been arranged, a formal agreement should next be drawn up, also on stamped paper, setting forth the general conditions of the bargain. One condition should always be that payment is to be made monthly for such part of the work as may be finished to entire satisfaction by the end of each month, and that the signing of the pay-list for any such portion as shall be paid for at the end of any month shall be held as a sufficient receipt for such sums as may have been paid and received on the work progressively.

It will, however, often prove convenient to have an additional receipt in full made out and signed in the usual account form as a voucher on the completion of the whole work. It is handier when submitting the estate accounts as a whole at the quarterly, half-yearly, or yearly terms.

From the statement on the pay-list as to the piece-work for the month, it appears that James Smith had opened 2000 yards of drains in Braidwood Hill enclosure, at 2d. per yard; that Angus Cameron had erected 1000 yards of wire-fence on the same enclosure, at 8d. per yard; and that John M'Gregor had built 1200 yards of stone wall on the enclosure of Thortown, at 2s. per yard. All of these sums are set down and paid, and signed for by the parties, each opposite to his account, and each across a revenue stamp as the amounts exceed £2.

From the addition of both subdivisions of this statement it therefore appears that £23, 14s. 6d. was paid for day-labour during the month, and £170 for piece-work—or in all, £193, 14s. 6d.; hence the forester will accordingly set down this amount on the credit side in his cash-book.

The **Cash-Book** is the next record in the order of the system. It is best kept by single entry, with single money columns. In this book every sum, no matter for what purpose disbursed, is entered as it is paid, and care must be taken to have a receipt or voucher for even the smallest sum paid, whatever this may be. This is absolutely necessary in the case of the forester, as he must of course render a

proper account of his employer's money. The following specimen page will show the author's mode of keeping an account of all sums paid out:—

CASH ACCOUNT—*Credit Side.*

JOHN WOODFORD, in Account with LORD E——D.

		Cr.
1894. May 8.	By Robert Manfred for scouring drains in Stockston Plantation, per contract, as per agreement and receipt	£7 10 0
" "	" James Strachan for one quarter of oats for forest horse, as per account	1 2 0
" "	" Samuel Walker for paper, note-books for foremen, pens and ink, &c., for the Forester's office, as per account	1 3 6
" 15	" travelling expenses, two days in visiting southern district of plantations	0 15 0
" "	" Robert Dickson for axes, saws, and hammers for workmen on western district of plantations, as per account	4 8 6
" 16	" John Mathewson, carpenter, Newlands, for a new cart for forest work, as per account . . .	5 18 0
" "	" Robert Welbeck for erecting a new tank in Bancroft Wood, in which to prepare timber for fencing purposes, as per account, with specification .	4 6 0
" 23	" travelling expenses, three days in inspecting operations on the western district of plantations. .	1 2 6
" 26	" pay-list of daily labour and piece-work, performed in the woods and plantations, for the month ending on the 27th instant, as per pay-list .	193 14 6
	Carry forward	£220 0 0

An improvement on the above, without causing any unnecessary trouble, will be found in the following simple form of cash-book:—

Date.	No. of Item.	Particulars of Expenditure.	No. of Voucher.	Amount £ s. d.

From the above example of the mode of keeping the cash-book it will at once be seen how simple and easy a matter it is for the forester thus to note down the particulars of any account that he pays, and the exact date of the transaction. This noting down of the sums the forester may have occasion to pay is so easily understood, that the above specimen page, which is supposed to contain the transactions of one month or four weeks, should be sufficiently clear without any explanatory remarks.

For the information of young men, however, who may not yet have had the opportunity of learning book-keeping, a few general remarks may be made in explanation of the items set down as paid in the cash-book. The first of these is £7, 10s. for scouring drains in Stockston Plantation. Now, with reference to this, it should be clearly understood that the forester, in making an agreement with any person for the performance of such work, should have a written statement drawn out, setting forth the exact nature of the work, and detailing how it is to be done, and that this agreement should be signed by the party contracting for it. When the forester pays the contractor, he should take a proper receipt from him, and fold this up along with the agreement, both of which should be properly labelled or docketed on the back or outer fold, so as the more readily to distinguish them at a glance from other documents among which they may happen to be filed. They may both be labelled and docketed in the way shown under:—

AGREEMENT.	RECEIPT.
ROBERT MANFRED, for Scouring Drains, Stockston Plantation, £7, 10s. 1*st May* 1894.	ROBERT MANFRED, for Scouring Drains, Stockston Plantation, £7, 10s. 8*th May* 1894.

Having settled with regard to the agreement for the scouring of the drains and paid for the work, both the agreement and the receipt should be tied together, and laid past with similar documents in a drawer or pigeon-holed press kept exclusively for the purpose. The advantages of such a mode of arrangement will be felt by the forester when, at the end of the year, he comes to make up a full statement of his accounts.

The same mode of dealing with the other accounts should be maintained throughout. The forester should never omit, when paying out money on his employer's business, not only to procure a proper receipt for it, but also to enter the sum in his cash-book at once on the same day on which it was paid, and to label the receipt or account, as the case may be, and lay it past in due order in his drawer.

In the more complete system of entering the Nos. of the items and of the vouchers, as suggested by the editor,—the system laid down by the Indian Forest Code, and found to work excellently, even with very large and complicated accounts,—the receipts are filed as vouchers with the monthly accounts. But it is merely necessary to note on the back of the original

agreement such an entry as the following:—"Paid 8th May 1894; see Item No. 1, Voucher No. 1, of Cash Account for May 1894."

With regard to the forester's own expenses, it is not necessary that he should show a receipt for every small sum he may have occasion to pay out while travelling on his employer's business. It will generally be sufficient if he present an account of such expenditure at the end of a month, quarter, half-year, or year, according as his books are settled. But, for the sake of exactness, he should never neglect to enter at once in his cash-book the sums for travelling immediately on their being disbursed.

With regard to the account entered in the cash-book for day-labour and piece-work, amounting to £193, 14s. 6d., it is of course understood that the receipts for the various items which go to make up this sum are shown in the pay-list itself, and therefore in the cash-book reference is made to this other book, where the receipts of the different hands and the contracting parties are to be seen.

In the same way, the forester will enter into the cash-book all sums he pays out during the year; and, at the end of the year, when the accounts are to be arranged for settlement, they will have to be entered into another book, a specimen of which will be given in its proper place.

The foregoing specimen-pages of books should be sufficient to give a practical idea of the method adopted with reference to the keeping of an account of the expenditure. It is, of course, equally necessary that books should be kept with reference to the income from woods. The first is what in the author's system is termed the **Private Sales Book**, a specimen sheet of which is given on page 451.

Any unnecessary multiplication of account-books is much to be deprecated. Ledgers and other forms of special record are of course unavoidable; but so far as the *Cash Account* is concerned, it should be as clear, concise, and comprehensive as possible. The editor suggests the following simple form of cash account, which is a modification and simplification of the form prescribed for all the officers in the Indian Forest Service:—

Debit.						Credit.					
Date.	No. of Item.	Particulars of Revenue.	Amount.			Date.	No. of Item.	Particulars of Expenditure.	No. of Voucher.	Amount.	
			£	s.	d.					£ s.	d.

By entering on the debit side *in red ink* all sums received from the agent or proprietor direct, and by making similar red ink entries on the

credit side regarding all disbursements made for establishment, rates, and similar regularly recurring charges, and by summarising these two classes of items in an abstract at the foot of the account, the monthly cash account will show at a glance, when balanced, how much actual revenue has been derived during the month, and what the true expenditure on works of planting, tending, improvement, utilisation of produce, &c., has amounted to.

To keep the debit account in one book and the credit account in another would entail a want of clearness without any compensating advantage that is apparent.

This embraces all sales of timber for which ready money is received. A book ruled in the way shown is, in the author's opinion, the most suitable form for registering small sales as they occur from time to time, and for which the money is paid at once; for in such cases it is not necessary to show anything more than the simple nature of the transaction, without reference to any future entries having regard to it.

The column on the left-hand side of the form is, of course, for the entry of the dates when the different sales are made; the next column is for the names of the purchasers, and after it comes a column for their places of residence. Next in succession is a column for the names of the different plantations from which the timber was sold; and following this is another for the description of wood. All of these are clearly shown on the specimen page.

As a matter of convenience for entering the different quantities of wood sold, five columns are divided off so that entries can be made respectively concerning the quantities disposed of (1) per ton, (2) per hundred trees, (3) per dozen trees, (4) per tree, and (5) per cubic foot. This arrangement makes the different matters of entry more simple than could otherwise be obtained in a book of this kind, in which brevity combined with explicitness is very desirable. A few of the entries given in this example may be described by way of explanation, although this is perhaps hardly necessary.

In the more complete form of cash-book recommended by the editor, these various particulars would also appear in the briefest and most comprehensive manner on the debit side. For convenience in tracing entries, however, a column should be opened as No. 2 on the left, headed "No. of Item in Cash Account." By referring from the cash account, guided by the entry made in the column "No. of Item," the full particulars are traceable at once for any further information that may be wanted.

The first entry made is in the name of John Ross, residing at Laggan, who, it appears, on the 1st of May, purchased from the plantation of Sluggan, 700 small Oaks at £5 per 100, and amounting to £35 in all. Passing the purchase made by James Grant on the 3rd of May, reference will next be made to that concerning William Urquhart of Eden on the 4th. From the account, it is set forth that,

SALES OF TIMBER BY PRIVATE CONTRACT IN THE WOODLANDS ON THE ESTATE OF LYNMORE during the Month of May 1894.

Date.	Names of Purchasers.	Residence.	Plantation from which Sold.	Description of Timber.	1. Tons.	2. Hundred Trees.	3. Dozen Trees.	4. Trees.	5. Feet.	Rate.	Amount.	Total.
1894 May 1	J. Ross	Laggan	Sluggan	Small Oaks	...	7	...	...	...	£5 0 0	£35 0 0	
„ 3	J. Grant	Eden	Burnside	Scots Pine Thinnings	...	9	...	...	...	2 10 0	22 10 0	
„ 4	W. Urquhart	Do.	Do	Paling Rails	...	...	145	...	...	0 3 0	21 15 0	
„ 14	J. Calder	Damhead	Eden	Burnwood	50	...	...	...	...	0 15 0	37 10 0	
„ 17	G. Wallace	Burnside	Strawn	Birch, for Powder-Wood	76	...	...	...	...	1 2 0	83 12 0	
„ „	D. M'Donald	Clury	Clury	Scots Pine	...	...	...	40	...	0 7 6	15 0 0	
„ 19	J. Cumming	Smiddy Boyne	Adam's Wood	Oak	...	...	...	...	270	0 2 6	33 15 0	
„ „	G. Ogilvie	Tulloch	Lait	Larch	...	...	...	...	590	0 1 0	29 10 0	
„ 23	W. Scott	Broomhill	Do.	Spar Wood	...	...	30	...	...	0 18 0	27 0 0	
„ 24	J. Dundas	Craggan	Damhead	Firewood	25	...	...	...	...	0 6 0	7 10 0	
„ „	G. Stewart	Slapp	Do.	Ash	...	...	...	...	75	0 1 6	5 12 6	
„ 25	A. Cameron	Do.	Strawn	Elm	...	...	...	...	215	0 1 8	17 18 4	
„ „	R. Ewan	Clayfolds	Do.	Decayed Trees	...	...	...	27	...	0 1 0	1 7 0	
				Totals	151	1,600	175	67	1,150	...	...	£337 19 10
				PAYMENTS FROM CREDIT ACCOUNTS IN LEDGER.								
„ 17	J. Gordon	Miltown	By Cash per Credit Account in Ledger, folio 1								£150 0 0	
„ 23	A. M'Gregor	Craigbea	Do. do. do., folio 2								68 0 0	
„ 26	W. Nimmo	Woodhead	Do. do. do., folio 3								120 0 0	
												333 0 0
										Grand Total	. .	£675 19 10

on that date, he had purchased from the plantation of Burnside paling-rails to the amount of 145 dozens of poles at 3s. per dozen, and that the amount of his purchase is £21, 15s. Reference need only be made to one other sale, viz., that on the 14th, to James Calder of Damhead, who is recorded as having bought firewood from the plantation of Eden to the extent of 50 tons. This, as is shown, was sold to him at 15s. per ton; and payment was made by him at once for the whole sum, amounting to £37, 10s. in all.

In entering such sales, they can be carried forward from page to page to any desired extent. Only a few have been shown, simply to illustrate the mode of keeping an account of such transactions. This may include one week's or one month's transactions; but in the specimen here given it is supposed to extend over one month's sales.

The great advantages resulting from this mode of keeping an account of wood sales are its simplicity, its exactness, and, not the least, its pointing out at a glance from what plantation each sale has been made. The latter is a very great advantage when correct accounts of the produce from each plantation is an object, as ought always to be the rule in every well-regulated establishment; for, without such information, the management of woods can never be clearly defined as to income and expenditure. It is of the greatest importance to be able to ascertain, at any time, what value of produce has been taken from a given plantation; without this, indeed, no proprietor can say whether any particular plantation has paid him better than any other, or whether it has ever been a financial success at all.

In the lower portion of the specimen sheet is also shown an account of payments made during the month by purchasers who had bought timber on credit. It is here supposed that this class of purchasers had bought produce from the woods on the understanding that they were to have a certain time allowed them for the purpose of making payment, and that they were to pay the balance as they found it convenient, within a reasonable time. Sales of this description are entered into another book, the **Ledger**, kept specially for the purpose. Before describing the nature of the entries made at the foot of the sales book, it may perhaps be well to illustrate the mode of keeping the account of such credit sales in the ledger. A specimen of this book is shown on pages 454–455.

From the examples shown in this specimen folio of the ledger, it is apparent that five different persons have running accounts with the forester during the month of May, for purchases of timber made by them respectively on credit, viz., John Gordon, Alexander M'Gregor, William Nimmo, John Maxwell, and Peter Grant, on account of various descriptions of produce.

It appears that John Gordon, on the 4th of May, purchased

from the Clury Plantation 370 trees at 9s. each, amounting to £166, 10s.; that at the same time he purchased also from the Lait Plantation 280 Larch-trees, at 15s. each, amounting to £210; and that on the 17th he purchased again from the Clury Wood 1160 ft. Scots Pine, at 9d. per foot, amounting to £43, 10s. It should be observed that these entries of sale are all entered on the left-hand or debit page of the book, and in regular order according to their dates. On the contra, right-hand, or credit page of the book, however, it will be observed that John Gordon, on the day that he made his last purchase in Clury Plantation, on the 17th, had paid to the forester £150. This sum is therefore entered on the right-hand page under date the 17th May, and on this side all sums are entered as they are paid.

The nature of this book, the Ledger, is simply that the sales made are entered on the left-hand page of each folio; whereas the payments, as they are made, are entered on the opposite page. Consequently, at any time it can be seen at a glance what sums are due and what have been paid; and, of course, when the sums on both sides are equal, the account is said to be balanced or settled.

In the same way as has just been described, all the accounts in the following folios of the ledger are entered and dealt with; and in a book of this kind there may be any number of purchasers entered for transactions, according to the extent of the sales made, on the principle of credit accounts. Care must be taken to give each purchaser a folio or double page for his account. In making such sales, however, the forester requires to be very careful as to whom he deals with. When would-be purchasers do not happen to be reliable men, a certain amount of risk is incurred if any of the timber be allowed to be removed from the woods before payment has been made for it in full. This matter should, therefore, be kept specially in view when entering into transactions of this description with parties whose business position is not well known and entirely trustworthy.

Reference may now be made to the items in the statement at the foot of the sales account specimen sheet. This item could not conveniently be referred to till now, as it is set down under the private sales as payments on credit accounts in ledger. In looking over this statement, it first of all appears that on the 17th of May John Gordon of Miltown had paid cash, as per credit account in ledger, folio (*i.e.* double page) 1, to the amount of £150. Now, as shown in the specimen folio of the ledger, and as may be seen by an examination of John Gordon's account, given at folio 1 of the ledger, this will be seen to correspond with the transaction as it took place; for, at folio 1 of the ledger, £150 is entered on the right-

SPECIMEN FOLIO OF THE LEDGER ACCOUNT.

Dr. JOHN GORDON, Wood Merchant, Miltown.

1894.	Plantation from which sold.	Description of Timber.	Tons.	Hundred Trees.	Dozen Trees.	Trees.	Feet.	Rate.	Amount. £ s. d.	Total.
May 4	Clury	Scots Pine	...	...	...	370	...	at 9/	166 10 0	
" "	Lait	Larch	...	...	...	280	...	at 15/	210 0 0	
" 17	Clury	Scots Pine	...	...	...	...	1160	at /9	43 10 0	

Dr. ALEXANDER M'GREGOR, Wood Merchant, Craigbea.

1894.	Plantation from which sold.	Description of Timber.	Tons.	Hundred Trees.	Dozen Trees.	Trees.	Feet.	Rate.	Amount. £ s. d.	Total.
May 1	Burnside	Scots Pine / Propwood	...	...	290	...	...	at 4/	58 0 0	
" 3	Lait	Larch Propwood	...	...	340	...	...	at 6/	102 0 0	

Dr. WILLIAM NIMMO, Saw-miller, Woodhead.

1894.	Plantation from which sold.	Description of Timber.	Tons.	Hundred Trees.	Dozen Trees.	Trees.	Feet.	Rate.	Amount. £ s. d.	Total.
May 14	Clury	Scots Pine	...	...	...	235	...	at 8/	94 0 0	
" 19	Damhead.	Small Ash	...	...	50	...	...	at 15/	37 10 0	
" "	Strawn	Small Sycamore	...	...	30	...	...	at 10/	15 0 0	

Dr. JOHN MAXWELL, Wood Merchant, Burnside.

1894.	Plantation from which sold.	Description of Timber.	Tons.	Hundred Trees.	Dozen Trees.	Trees.	Feet.	Rate.	Amount. £ s. d.	Total.
May 17	Adam's Wood	Oak Timber	...	...	...	...	1200	at 2/3	135 0 0	
" 23	Do.	Oak Burnwood	110	...	...	...	...	at 12/	66 0 0	
" 26	Clury	Oak Spokewood	...	...	...	500	...	at 1/6	37 10 0	

Dr. PETER GRANT, Wood Merchant, Ballintua.

1894.	Plantation from which sold.	Description of Timber.	Tons.	Hundred Trees.	Dozen Trees.	Trees.	Feet.	Rate.	Amount. £ s. d.	Total.
May 1	Clury	Scots Pine	...	...	...	700	...	at 8/	280 0 0	
" 14	Do.	Do.	...	...	...	...	1300	at /9	48 15 0	
" 26	Do.	Scots Pine / Paling Wood	...	...	70	...	...	at 8/	28 0 0	

CONTRA. *Cr.*

1894.	Mode of Payment.	Discount.	Sums Paid.
			£ s. d.
May 17.	By cash to account	... ...	150 0 0

CONTRA. *Cr.*

1894.	Mode of Payment.	Discount.	Sums Paid.
			£ s. d.
May 23.	By cash to account	... ...	68 0 0

CONTRA. *Cr.*

1894.	Mode of Payment.	Discount.	Sums Paid.
			£ s. d.
May 26.	By cash to account	... ...	120 0 0

CONTRA. *Cr.*

1894.	Mode of Payment.	Discount.	Sums Paid.

CONTRA. *Cr.*

1894.	Mode of Payment.	Discount.	Sums Paid.

hand side of the page, to the credit of John Gordon. From the same statement it next appears that Alexander M'Gregor had paid, on the 23rd of May, cash to the amount of £68; and for the particulars of the transaction, the statement refers to the ledger at folio 2. Looking this up in the ledger, it is seen at folio 2 that this exactly corresponds with the transaction for £68 which is entered to the credit of A. M'Gregor in the account opened up with him on folio 2. Again, it also appears that on the 26th May, W. Nimmo had made a payment of £120. This is referred to the 3rd folio of the ledger, where the transactions with reference to this purchaser are fully particularised on the left-hand page; whilst on the right or credit side, it is shown that on the 26th of May he paid in the sum stated, and is given credit for it in the usual way.

The payments made from these three men are all recorded in the sales book, where they in reality form a short abstract of the ledger accounts opened during the month of May. As they are shown to amount in all to £338, this sum is set down in the columns for the total receipts of the month, and under the totals received from the ready-money sales; and thus it is exhibited that the amount received for timber from sales by private contract during the month of May is in all £675, 19s. 10d. All the particulars with regard to these sales are therefore traceable in the ready-money transactions in the current month's sales book, and in the ledger where the credit sales are particularised at the folios referred to in the ledger abstract at the foot of the monthly sales book.

This is all so plain that little further comment seems required on the subject. It may be remarked, however, that the two purchasers, John Maxwell and Peter Grant, are represented as having made no payments during the month of May. This is, of course, at once seen by no sums being entered to their credit on the right-hand pages of their account folios; so that all the timber they have previously bought appears to be still unpaid for, even in part.

Special attention must be given to the subject of registering the transactions of sales of timber by public auction. These, generally speaking, are more complicated than sales made by private contract, inasmuch as the transactions are generally more extensive than most private contracts, and also as they are to be guided by the conditions of roup that are always laid down, and that must be attended to by the seller on the one part, as well as by the buyer on the other.

For the sake of illustrating how public sales of timber should be registered in a book, it may be supposed that reference is still being made to the disposal of the Larch and Pine trees referred to in the statement given with regard to the estimate of the probable income detailed on page 434. By referring to that estimate, it will be

observed that proposals were made that there should be sold from the Hill of Bands, by public auction, 10,000 Larch-trees; and it was supposed that they would amount in value to 10s. each, or £5000 in all. It was also proposed that there should be 12,000 Scots Pine-trees sold from the plantation of Gorry; and it was expected that they should bring 6s. each, or £3600 in all. The Oak timber referred to in the paragraph need not be noticed at present, as it is to be understood that it cannot be had stripped and held in readiness for sale so early as the month of May, when the sale of Pine and Larch is supposed to take place.

Preparatory to this sale, then, the number of trees stated should be properly divided into lots, of various numbers, to suit the requirements of small and large purchasers, and to induce such competition as may realise the highest possible price for each lot, and for the whole.

It may now be supposed that all these preliminary arrangements have been made, that the 10,000 Larch-trees to be sold have been properly marked and arranged for sale, that they are subdivided into 10 different lots, varying from 250 to 3000 trees, and also that the 12,000 Scots Pines have been dealt with in a similar manner, and subdivided into 17 different lots, varying from 250 to 2000 trees each. This would make a total of 27 lots to be disposed of. These arrangements having all been made, and the timber sold, say on the 4th day of May, all the different lots, and the whole of the money transactions in regard to them, should be entered into a book for the purpose, as shown on the next page. This specimen sheet is in every respect a copy of the way in which the author was in the habit of keeping his own books for the registration of similar transactions.

The above-named is the form of book in which the author was accustomed to register his sales of timber by public auction; he adopted it for a considerable number of years, and found it to answer all purposes admirably. The headings point out the different details which it records, so that little description is required in explanation. A few remarks may, however, be made to show the manner of entering the particulars of a sale.

The 1st column, as indicated by the heading, is for entering the names of the plantations in which the timber is sold; and the 2nd indicates the date on which the sale takes place. From the entry in the first column it is shown that the sale under consideration took place in the plantation called the Hill of Bands, and on the 4th of May. The 3rd column indicates the numbers of the respective lots sold; the 4th details the kinds of trees the lots consisted of; and the 5th states the number of trees in each lot respectively. Hence, in continuing

SALES OF TIMBER BY PUBLIC AUCTION ON THE ESTATE OF LYNMORE ON 4TH MAY 1894.

1. District or Plantation in which Sold.	2. Date of Sale.	3. No. of Lot.	4. Description of Timber.	5. Quantity.	6. Name of Purchaser.	7. Residence.	8. Rate.	9. Value.	10. Total Amount.	11. Discount.	12. Date of Payment.	13. Cash Received.	14. Sums Due.	15. Date of Full Payment.	16. Full Payment.	17. Remarks.
				Trees.				£	£		1894.	£ s. d.	£ s. d.			
Hill of Bands	May 4	1	Larch	3000	J. Ream	E——d	Per Lot	1700								Settled by Bills at 4 & 8 Months after date
...	...	2	...	500	...	...	...	260								
									1960		May 4	490 0 0	1470 0 0			
...	...	3	...	300	J. Morison	E—— d	...	160								
									160		...	40 0 0	120 0 0			...
...	...	4	...	400	R. Murray	L——e	...	200								
...	...	5	...	250	...	...	...	140								
...	...	6	...	450	...	...	...	270								
									610		...	152 10 0	457 10 0			...
...	...	7	...	2000	J. Ramsay	K——o	...	1050								
...	...	8	...	1000	...	...	...	600								
									1650		...	412 10 0	1237 10 0			...
...	...	9	...	1500	J. Kemp	L——l	...	800	800		...	200 0 0	600 0 0			...
...	...	10	...	600	R. Webster	L——e	...	300	300		...	75 0 0	225 0 0			...
			Trees	10,000					5480			1370 0 0				
Plantation of Gorry	...	11	Scots Pine	1000	J. Nicholson	N——e	...	310								
	...	12	...	500	...	...	...	170								
...	...	13	...	500	...	...	...	150								
...	...	14	...	700	...	...	...	230								
...	...	15	...	300	...	...	...	100								
									960		...	240 0 0	720 0 0			...
...	...	16	...	500	R. Reid	L——d	...	160								
...	...	17	...	1000	...	...	...	340								
...	...	18	...	700	...	...	...	220								
									720		...	180 0 0	540 0 0			...
...	...	19	...	300	S. Johnston	W——e	...	100								
									100		...	25 0 0	75 0 0			...
...	...	20	...	800	J. Grant	G——n	...	250								
...	...	21	...	700	...	...	...	240								
									490		...	122 10 0	367 10 0			...
...	...	22	...	2000	W. Stewart	G——n	...	650								
...	...	23	...	2000	...	...	...	580								
									1230		...	307 10 0	922 10 0			...
...	...	24	...	250	R. France	E——h	...	80								
...	...	25	...	250	...	...	...	75								
...	...	26	...	250	...	...	...	70								
...	...	27	...	250	...	...	...	74								
									299		..	74 15 0	224 5 0			...
			Trees	12,000					3700			949 15 0				

the reading of the first line, it will be seen that the first lot consisted of Larch to the number of 3000 trees. The 6th column indicates that this lot was sold to John Ream, and the 7th that his residence is at E——d; the 8th, that the timber is sold *per lot*, without reference to any other specified quantity or mode of measurement; the 9th, that the entire value of the 1st lot, as purchased by him, is £1700. The first line finishes at this point, because this same John Ream has also bought lot 2, which consists of 500 Larch-trees, sold to him at the price of £260. These two sums—£1700 for lot 1, and £260 for lot 2—exhibit £1960 as the total amount of this purchaser's debit; and this is therefore set down in the 10th column, which is adapted by its heading for this purpose. Passing the 11th column, which is set apart for entering any discounts that may be allowed, it will be seen from the 12th and 13th columns that on the 4th day of May, the day on which the timber is supposed to have been sold, John Ream paid, as a deposit or earnest-money, one-fourth part of the price of his purchases, £490, in conformity with the conditions of sale. Next, from column 14th, it will be seen at a glance that after the sale, and after he has made his first part payment, this purchaser is due £1470, which of course constitutes exactly the remaining three-fourths of the total price of his purchases. Columns 15 and 16 are for use when further payments come to be made, and therefore, in the meantime, are left blank till such are forthcoming. But from the 17th column it may be seen that John Ream settled for the balance due by him, by granting his bills for payment at four and eight months after the date of the sale; and so on with all the other lots as they are shown under the names of the different purchasers respectively. From this tabular statement, therefore, a most complete account is given of each of the lots sold, in a clear, distinct, and satisfactory manner, that may easily be recorded for any subsequent reference.

The author considers that no other system of book-keeping is so well adapted to answer the requirements concerning sales by public auction as that given in the foregoing form. It is simple and clear, as well as concise, and therefore takes up little space in a book.

It may be observed, under the 3rd column, that the Larch timber is embraced in the first 10 lots, and was therefore first sold; that the Scots Pine timber commences at lot 11, and is embraced in the following lots to 27. The number of Larch-trees (10,000) will be observed to correspond with the number stated in the estimate of proposed income stated on page 434, as proposed to be sold; whilst the quantity of Scots Pine (12,000) also corresponds with the quantity mentioned in that statement. But on comparing the results of the sale with the sums stated as the value of the trees respectively in the

estimate of the proposed income, it will be found that there is a considerable difference.

On page 434 it was estimated, with reference to the income expected from the 10,000 Larch-trees, that their value might probably be £5000, and in reference to the 12,000 Scots Pine-trees, that their value might probably be £3600; while the result of the sale, in the 10th column, shows £5480 for the Larch, and for the Scots Pine £3799, thus making, as the sum realised in all, £9279—instead of £8600, as was expected—or £679 more than the estimated value. Such a result as here indicated often takes place at public sales; for, however judiciously any forester may value his wood, it may bring more or less, according to the demand for the sort of timber at the time of sale.

Having made the foregoing remarks in explanation of the form of book for public sales of timber, there seems no necessity for enlarging any further on the subject. The young forester may, however, be requested to consider and study very carefully the character of the different books, of which specimen pages have been given, for exhibiting all the above details of expenditure and income. Unless he does this, and acquires a clear view of the whole subjects the specimens are meant to present to him, he will scarcely be in a position to keep correct accounts, whether of expenses for work performed or of income from produce sold. All of the books described are absolutely necessary for every forester to keep, in order to be able to lay before his employer a sensible and intelligent statement at the end of the year, embracing all the transactions and works he has had performed, and detailing all the produce he has sold. Without some such well-defined system, the business details under his charge must eventually run into confusion.

The books that have been described, and of which specimen pages have been given, are as follows:—

1. ESTIMATE OF THE PROBABLE INCOME FROM, AND EXPENDITURE ON, THE WOODS AND PLANTATIONS ON THE ESTATE OF LYNMORE, FOR THE YEAR FROM 1ST MAY 1894 TO 30TH APRIL 1895. This book may be of any convenient size to suit the extent of business likely to be performed, and ought at least to contain so many pages as to admit of its holding all transactions for a considerable number of years. It may be obtained from any stationer in a large town, ruled as shown in the copy, bound and ready for use; but, of course, on the forester ordering such a book from a stationer, he will require to give him a specimen-sheet to guide him in ruling the pages. The principal headings may be all printed, which will give the book a neater and more business-like character.
2. THE DAILY-LABOUR BOOK (copy shown for the first four weeks of the supposed year). This book should be made to contain the labour transactions of one year, and should be labelled outside DAILY-LABOUR BOOK FOR THE WOODS AND PLANTATIONS ON THE ESTATE OF ——— FOR

THE YEAR ———. Such a book may also be had from any stationer, by giving him a copy to rule from. All the headings should be printed, as this will be a saving of time to the forester, and may be the means of preventing mistakes.

3. ACCOUNT OF DAILY-LABOUR AND PIECE-WORK PERFORMED IN THE WOODS AND PLANTATIONS, &c. This book should also be made to hold the transactions of one year, and, as in the case of the Daily-Labour Book, should be labelled outside. At the end of the year, both can be laid past together as documents referring to the same year.
4. THE CASH-BOOK. This one may be of any convenient size to suit the transactions of the estate, and is most convenient when it is large enough to hold the transactions of a considerable number of years.

There should be loose folios of the cash-book as well as a bound book. The loose folios can then very conveniently be used in submitting monthly accounts, as would be the practice on large estates under the general management of a land-steward having control of all operations on behalf of the proprietor.

The four books above mentioned are all that are necessary in connection with the labour department of the woods, as no description of labour can possibly take place which may not be properly detailed in them. The special books of reference with regard to income, of which specimen sheets have been given in their respective places, include the following:—

5. ACCOUNT OF SALES OF TIMBER BY PRIVATE CONTRACT. This description of book may be made either of dimensions sufficient to hold the sales of one year only, or those of several years, according to the business habits of the proprietor. Those in use with the author contained many pages, so as to hold the sales of several years; and this, he thinks, is the most convenient form of keeping them.
6. THE LEDGER. This is a book which generally requires to be rather large, in order to admit of a few folios being set aside for each purchaser. It should also be provided with an alphabetical index at the beginning, by means of which to find out readily the folios of the parties to whom the wood is sold. This is of course managed by the purchasers being registered on the index, according to the first letter of their names; and when their names are being registered in the index, reference is made to the folio upon which their particular transactions are detailed.
7. ACCOUNT OF SALES OF TIMBER BY PUBLIC AUCTION, &c. This is a very important description of book on most wooded estates; and therefore it should be made of a fairly large size, so as to be sufficient to hold the transactions of several years.

All these seven books referred to should be well bound, and never slimly in paper boards. When put together in a flimsy manner, they soon become shabby-looking from the great amount of handling they must necessarily get. And besides that, they are apt to get torn; hence it is always a matter of economy to have all such account-books well bound in leather.

Although these seven books are sufficient for all the ordinary purposes of keeping accounts with regard to the expenditure and income of woodlands, still the book-keeping of the forester could not be said to be complete with those alone. At the end of each year, he must render to his employer a correct and formal account of all the transactions he has performed during the year past. For this purpose other two books are in use. These are respectively the **Comparative Statement as to Estimated and Actual Income and Expenditure** and the **Statement of Income and Expenditure.** A copy of the former is annexed (see pages 463–466, also editor's remarks on pages 437, 449).

For the sake of completeness, and for ready reference, it is of advantage to exhibit on the facing page of the annual accounts a short comparative abstract in the following form :—

ABSTRACT.

Year 1894–1895.	Estimated.	Actuals.	Increase. +	Decrease. −
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Income or Revenue . .	11,779 2 0	12,525 11 10	746 9 10	...
Expenditure . . .	3,791 14 10	3,784 16 1	...	−6 18 9
Net Income or Revenue .	7,987 7 2	8,740 15 9	+753 8 7	...

A glance may conveniently be taken at the foregoing statement, with the view of giving a short explanation of what it is meant to represent, and of showing the use of keeping such a book. Its object is to embrace, in one comprehensive statement or abstract, all the transactions of each year, which have been duly performed in accordance with the scheme supposed to be drawn up, submitted, and approved at the beginning of the year, in the manner shown in the Statement of the Estimate of the Probable Income and Expenditure, &c., a copy of which was given as the first specimen in this system of book-keeping. It is specially designed not only to embrace all the transactions of the year, but also to compare the sums actually received and expended on each subdivision of work at the end of the year with those that were estimated as probable at the beginning.

Taking a glance at the debit or income side of the statement just given, it will be seen that the first column indicates the different woods from which produce was sold, whilst the second column gives the description of produce. The third column indicates the quantities of timber sold by public auction and the sums actually realised for each sort and quantity; and this of course should correspond with the results stated in detail in the public-sales book. The fourth

Dr. from 1st May 1894 to 30th April 1895.

1. Name of District from which sold.	2. Description of Produce.	3. Sales by Public Auction. Quantity or Measurement.	3. Amount actually realised.	4. Sales by Private Contract. Quantity or Measurement.	4. Amount actually realised.	5. Total. Quantity or Measurement.	5. Amount actually realised.	6. Comparison of Actual and Estimated Income. 1. Actual Income.	2. Estimated Income.	3. Sums under Estimate.	4. Sums over Estimate.	Difference between Actuals and Estimate.	Remarks.
		Trees.	£ s. d.				£ s. d.	£ s. d.	£ s. d	£ s. d.	£ s. d.	£ s. d	
Hill of Bands . .	Larch	10,000	5480 0 0			10,000	5,480 0 0	5,480 0 0	5,000 0 0		480 0 0		
Gorry Plantation .	Scots Pine . .	12,000	3799 0 0			12,000	3,799 0 0	3,799 0 0	3,600 0 0		199 0 0		
		Feet.											
Adam's Wood . .	Oak	3,000	375 0 0			3,000	375 0 0	375 0 0	625 0 0	250 0 0			£234, 15s. included in private sales.
				Trees.	£ s. d.								
Burnside, Woodhead, Clury, Laggan, and Lait. .	Larch and Pine thinnings . .			5100	824 15 6	5,100	824 15 6	824 15 6	700 0 0		124 15 6		
Rettie, Sluggan, and Eden	Young Oak thinnings . . .			4000	354 9 0	4,000	354 9 0	354 9 0	400 0 0	45 11 0			
Damhead & Strawn Plantations . .	Mixed Hardwood thinnings . .			3000	184 10 4	3,000	184 10 4	184 10 4	200 0 0	15 9 8			
				Feet.									
Adam's Wood . .	Clearings . . .			1470	168 15 0		234 15 0	234 15 0			234 15 0		
				Tons.									
				110	66 0 0								
" . " . .	Oak-bark . . .			59	309 15 0	59	309 15 0	309 15 0	250 0 0		59 15 0		This sum, although realised from private sales, was estimated on public sale from Adam's Wood.
Sluggan and Eden .	Young Oak-bark			67	519 5 0	67	519 5 0	519 5 0	560 0 0	120 15 0			
			9654 0 0		2427 9 10								

VALUE OF TREES AND PLANTS REMOVED FROM NURSERY TO PLANTATIONS.

Name of Plantation in which Planted.	Kinds of Plants.	Number of each.	Age.	Rate per 1000.	Amount.									
			Years.		£ s. d.									
Thortown Bridge . .	Oak . .	40,000	4	30s.	60 0 0				60 0 0					
Do. do. . .	Ash. . .	16,000	4	25s.	20 0 0				20 0 0					
Do. do. . .	Elm . .	4,000	3	25s.	5 0 0				5 0 0					
Do. do. . .	Larch . .	200,000	2	10s.	100 0 0				100 0 0					
Braidwood Hill . .	Scots Pine .	400,000	2	6s.	120 0 0				120 0 0					
Do. do. . .	Spruce . .	6,000	4	12s.	3 12 0	308 12 0	308 12 0	308 12 0	3 12 0					40,000 Scots Pine were used in the Thortown Bridge enclosure, as per statement of expenditure on planting.
		666,000												
Westergates . . .	Thorns . .	10,000	4	15s.	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0					
Rent of Sawmills						110 0 0	110 0 0	110 0 0	110 0 0					
Rent of Cottages						18 0 0	18 0 0	18 0 0	18 0 0					
Total Income . .						12,525 11 10	12,525 11 10	11,779 2 0				746 9 10		Over Estimate.

The weight of bark actually got from these woods is 13 tons under that estimated for, and the price per ton is also 10s. under that anticipated.

Braidwood Hill Enclosure—						
34 acres of, at £3, 3s. per acre	107 2 0	90 0 0		17 2 0		
Thortown Bridge Enclosure—						
39 acres of, at £2, 18s. per acre	108 2 0	146 5 0	38 3 0			
Total for Draining	215 4 0	236 5 0	38 3 0	17 2 0	21 1 0	Under Estimate.
Planting:—						
Braidwood Hill Enclosure—						
360,000 Scots Pine, at 6s. per 1000	108 0 0	108 0 0				
6,000 Spruce, at 12s. per 1000	3 12 0	3 12 0				
366,000						
Expense of planting	45 15 6	54 18 0	9 2 6			
Carriage of plants	3 0 0	4 0 0	1 0 0			
Thortown Bridge Enclosure—						
40,000 Oak, at 30s. per 1000	60 0 0	60 0 0				
16,000 Ash, at 25s. per 1000	20 0 0	20 0 0				
4,000 Elm, at 25s. per 1000	5 0 0	5 0 0				
Making 60,000 pits for Hardwood, at 1s. per 100	30 0 0	30 0 0				
200,000 Larch, at 10s. per 1000	100 0 0	100 0 0				
40,000 Scots Pine, at 6s. per 1000	12 0 0	12 0 0				
600,000						
Expense of planting	52 10 0	45 0		7 10 0		
Carriage of plants	7 0 0	6 0 0		1 0 0		
Total for Planting	446 17 0	448 10 0	10 2 0	8 10 0	1 12 0	Under Estimate.
Carry forward	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Details of Expenditure.	Comparison of Actual and Estimated Expenditure. Actual Expenditure. £ s. d.	Estimated Expenditure. £ s. d.	Sums under Estimate. £ s. d.	Sums over Estimate. £ s. d.	Difference between Actuals and Estimated. £ s. d.	Remarks.
Brought forward	1967 19 4	2051 8 4	119 18 5	36 9 5		
Lodges:—						
Repairs of	79 11 6	70 0 0		9 11 6		
Total for Lodges	79 11 6	70 0 0		9 11 6	9 11 6	Over Estimate.
Water-runs:—						
Repairs on sides of	97 0 0	110 0 0	13 0 0			
Total for Water-runs	97 0 0	110 0 0	13 0 0		13 0 0	Under Estimate.
Sawmill Dams:—						
Repairs of	33 2 9	30 0 0		3 2 9		
Total for Mill-dams	33 2 9	30 0 0		3 2 9	3 2 9	Over Estimate.
Roads, Rides, and Walks:—						
New road from Saltown Bridge to Westergates— 2326 yards, at 1s. 6d. per yard	174 9 0	172 10 0		1 19 0		
Repairs of roads generally	23 10 9	30 0 0	6 9 3			
Repairs of rides	21 17 6	18 0 0		3 17 6		
Repairs of walks, and cleaning	35 9 6	40 0 0	4 10 6			
Total for Roads, &c.	255 6 9	260 10 0	10 19 9	5 16 6	5 3 3	Under Estimate.
Hedging:—						
On side of new road betwixt Saltown Bridge and Westergates						
Preparing 1690 yards of bed for Thorn plants, at 6½d. per yard	45 15 5	41 13 0		4 2 5		
10,000 plants, at 15s. per 1000	7 10 0	7 10 0				
Expense of planting	3 2 9	2 10 0		0 12 9		
Carriage of plants	0 3 10	0 5 0	0 1 2			
Cleaning of hedges generally	49 13 5	60 0 0	10 6 7			
Switching of hedges	47 19 6	50 0 0	2 0 6			
Total for Hedging, &c.	154 4 11	161 18 0	12 8 3	4 15 2	7 13 1	Under Estimate.
Felling and Preparing Oak Timber:—						
In Adam's Wood, for sale	15 0 0	12 10 0		2 10 0		
Total for Felling Timber	15 0 0	12 10 0		2 10 0	2 10 0	Over Estimate.
Stripping and Curing Oak Bark:—						
126 tons, at £2, 12s. 6d. per ton	330 15 0	325 0 0	- - -	5 15 0		
Total for Oak Bark	330 15 0	325 0 0		5 15 0	5 15 0	Over Estimate.
Thinning:—						
Burnside, Woodhead, Clury, Laggan, and Lait Plantations	206 0 0	235 0 0	29 0 0			
Rettie, Sluggan, Eden, Damhead, and Strawn Plantations	134 0 0	60 0 0		74 0 0		
Total for Thinning	340 0 0	295 0 0	29 0 0	74 0 0	45 0 0	Over Estimate.
Clearing and Burning Rubbish:—						
From cleared land, Heathfield Enclosure	34 1 9	30 0 0		4 1 9		
Total for Burning Rubbish	34 1 9	30 0 0		4 1 9	4 1 9	Over Estimate.
Carry forward	3307 2 0	3346 6 4	185 6 5	146 2 1		

COMPARATIVE STATEMENT AS TO THE ESTIMATED AND ACTUAL INCOME AND EXPENDITURE ON THE WOODLANDS ON THE ESTATE OF LYNMORE, from 1st May 1894 to the 30th April 1895.

Cr.

Details of Expenditure.	Comparison of Actual and Estimated Expenditure.																														REMARKS.
	Actual Expenditure.			Estimated Expenditure.			Sums under Estimate.			Sums over Estimate.			Difference between Actuals and Estimate.			
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	
Pruning :— Brought forward	3307	2	0	3346	6	4	185	6	5	146	2	1				
Rymore young Oak plantation		4	15	4		8	0	0		3	4	8																			
On sides of approach road *		6	2	6										6	2	6															* Not estimated for.
Total for Pruning		10	17	10		8	0	0		3	4	8		6	2	6		2	17	10											Over Estimate.
Nursery :—																															
Plants used—																															
20,000 Oak		7	10	0		7	10	0																							
9,800 Ash		3	8	7		3	10	0		0	1	5																			
3,000 Elm		1	2	6		1	2	6																							
150,000 Larch		18	0	0		18	0	0																							
300,000 Scots Pine		51	0	0		51	0	0																							
2,000 Silver Fir		0	15	0		0	15	0																							
5,000 Spruce Fir		0	15	0		0	15	0																							
2,500 Sycamore		1	5	0		1	0	0						0	5	0															
600 Lime-tree		4	10	0		3	15	0						0	15	0															
550 New Coniferæ		27	10	0		25	0	0						2	10	0															
8,000 Thorn		6	0	0		6	0	0																							
501,450 Total for Plants		121	16	1		118	7	6		0	1	5		3	10	0		3	8	7											Over Estimate.
Nursery Labour :—																															
Laying 501,000 plants at 9d. per 1000		18	16	0		25	1	0		6	5	0																			
Cleaning		6	17	0		8	0	0		1	3	0																			
Lifting		8	1	9		6	0	0						2	1	9															
Digging		7	11	5		7	0	0						0	11	5															
Manure		6	15	0		5	0	0						1	15	0															
Total for Labour		48	1	2		51	1	0		7	8	0		4	8	2		2	19	10											Under Estimate.
Travelling expenses of forester and assistant		30	15	6		25	0	0						5	15	6															
Stationery		15	11	10		8	0	0						7	11	10															
Criminal prosecutions		27	5	6		35	0	0		7	14	6																			
Carpenter-work		10	17	0		4	0	0						6	17	0															
Smithy-work		12	19	0		10	0	0						2	19	0															
Ironmongery		7	2	6		8	0	0		0	17	6																			
Keep of forest work-horse		26	10	0		25	0	0						1	10	0															
Wages of carter		30	0	0		30	0	0																							
Repairs of harness (or saddlery)		4	3	6		3	0	0						1	3	6															
Advertisements of timber sales		12	15	0		15	0	0		2	5	0																			
Sale dinners		15	12	7		10	0	0						5	12	7															
Printing catalogues and bills		6	5	6		5	0	0						1	5	6															
Auctioneer's charges		9	17	6		10	0	0		0	2	6																			
Rates and taxes		87	3	7		80	0	0						7	3	7															
		296	19	0		268	0	0		10	19	0		30	18	0		28	19	0											Over Estimate.
Total Expenditure		3784	16	1		3794	15	10		207	0	0		206	1	8		9	18	9											Under Estimate.

column, again, indicates the quantities sold by private contract, and the sums actually realised for each sort and quantity; this should, of course, correspond with the details and results of the private sales-book, and with those detailed in the sales entered in the ledger. The fifth column shows the entire quantities sold, and the whole of the money realised for them; and into this column is entered the value of all plants that have been removed from the nursery to the enclosures.

Under the main column, No. 6, a comparison is made between the actual and the estimated income, and any difference noticeable is recorded in the final, marginal, or remark column, with a brief explanatory note, if necessary, on account of any large divergence between the estimate and the actuals. Thus, in the various columns under No. 6 it is shown (1.) that the sum actually received for the 10,000 Larch-trees sold from the Hill of Bands is £5480; (2.) that £5000 only was estimated as their value; and (3.) that they realised £480 over their estimated value; and so on with the other items detailed.

The final information given by the debit side of this statement shows at a glance, under column No. 3, that £9654 was realised during the year from public sales, and under column No. 4 that £2427, 9s. 10d. was obtained from private sales. But, besides this, it is shown under sub-column 1 of the main column No. 6 that £12,525, 11s. 10d. was realised as the whole value of produce of all sorts during the year; and under sub-column 2 of the same main column, that only £11,779, 2s. was expected to be realised. Hence sub-column 5 of the main column No. 6 shows that £746, 9s. 10d. has been realised over and above what was expected at the beginning of the year, when the estimate of probable income and expenditure for the year was drawn up, submitted, and approved.

On the credit or expenditure side of the statement the same mode of comparison is followed with regard to the sums under the different operations therein set forth. As so much has already been said in explanation of the income side, it will be unnecessary to say much with reference to the expenditure, as the different headings speak for themselves. A short reference may, however, be made to two of the classifications of outgoings.

Under the heading of *Salaries and Allowances* it will be seen that the actual expenditure at the end of the year was exactly the same as that estimated for at the beginning of it, as is, of course, easily intelligible.

Under the heading of *Fencing* it is shown that the wire-fence which was erected on Braidwood Hill enclosure cost £6, 0s. 5d. more than was exhibited in the approved estimate; that the stone wall erected on Thortown Bridge enclosure cost £51, 6s. 3d. less than the estimate; that the general repairs of fences cost £20, 6s. 8d. less than estimated;

ANNUAL ESTATE ACCOUNT OF THE

Dr.

RECEIPT AND EXPENDITURE from the

To RECEIPT—						
Sales of Produce by Public Auction.						
From sales of Larch and Pine timber in the Plantations of Gorry and Hill of Bands on the 4th May 1894, as per Public-Sales Book . .	£9279	0	0			
From sales of Oak timber in Adam's Wood on the 24th August 1894, as per Public-Sales Book .	375	0	0			
				£9654	0	0
Sale of Produce by Private Contract.						
As per Private-Sales Book	2427	9	10			
				2427	9	10
Rent of sawmills for the year ended 30th April 1894				110	0	0
Rent of cottages for the year ended 30th April 1894				18	0	0
Carry forward				£12,209	9	10

LYNMORE WOODS.

1st May 1894 to 30th April 1895.

No. of Voucher.					Cr.
	EXPENDITURE—				
	Salaries and allowances—				
1.	John Baxter, forester, for year ended 30th April 1894	£300	0	0	
2.	Do., allowance for horse, do.	30	0	0	
3.	George Gillian, assistant to forester, for year ended do.	100	0	0	
4.	Do., allowance for horse, do.	30	0	0	
5.	William Turnbull, clerk to forester, do.	60	0	0	
6.	Peter Sangster, allowance for looking after western district, one year, ended do.	40	0	0	
7.	George Jopp, do. eastern district, do.	40	0	0	
8.	Robert Bruce, do. northern district, do.	40	0	0	
9.	Maxwell Hay, do. southern district, do.	40	0	0	
					£680 0 0
Vouchers in Monthly Pay-List.	Pay-Lists of day-labour and piece-work for the month ended 26th May 1894	193	14	6	
	" " 30th June "	386	15	6	
	" " 28th July "	170	10	9	
	" " 1st Sept. "	163	2	6	
	" " 29th do. "	235	9	4	
	" " 3rd Nov. "	142	7	6	
	" " 1st Dec. "	167	0	0	
	" " 29th do. "	150	2	10	
	" " 1st Feb. 1895	96	15	7	
	" " 2nd March "	135	19	4	
	" " 30th do. "	296	7	3	
	" " 38th April "	141	18	7	
					2280 3 8
	Young trees for nursery—				
10.	John Stoddart, Muirhead	67	12	9	
11.	James Maxwell, Newtown	30	10	3	
12.	George Simpson, Rafford	23	13	1	
					121 16 1
	Carriage of young trees—				
13.	Lauchlan Grant, Newtown	2	7	6	
14.	Wm. M'Kenzie, Lynstock	5	19	3	
15.	George Sutherland, Mayen	1	17	1	
					10 3 10
	Carpenter-work—				
16.	John Mathieson, Newlands	5	18	0	
17.	Robert Welbeck, Bencroft	4	6	0	
18.	Samuel Murison, do.	0	13	0	
					10 17 0
	Smithy-work—				
19.	Robert Dickson, Rosieburn	4	8	6	
20.	Donald Fife, Craigstown	5	17	0	
21.	Alexander Laing, Smiddyseat	2	13	6	
					12 19 0
	Lodges, Repairs of—				
22.	James M'Kinnan, mason, Pitgair	62	14	10	
23.	George Urquhart, carpenter, do.	15	13	4	
24.	William Sim, painter, do.	1	3	4	
					79 11 6
	Carry forward				£3195 11 1

ANNUAL ESTATE ACCOUNT OF THE

Dr.

RECEIPT AND EXPENDITURE, from the

To amount brought forward . .	£12,209 9 10
	£12,209 9 10

LYNMORE WOODS.

Cr.

1st May 1894 to 30th April 1895—(*continued*).

No. of Voucher.					
	By amount brought forward . .			£3195 11 1	
	General stationery—				
25.	Samuel Walker	£1 3 6			
26.	Wm. Smith, jun.	7 1 2			
27.	Robert Dunbar	5 11 4			
28.	George Fowlie	1 15 10			
				15 11 10	
	Expenses on sales of timber—				
29.	George Ramsay, advertisements . .	6 2 3			
30.	Wm. Walker, do. . . .	6 12 9			
31.	Wm. Murison, sale dinners . . .	15 12 7			
32.	George Ramsay, printing catalogues .	6 5 6			
33.	James Skinner, auctioneer . . .	6 14 6			
34.	Do. do. . . .	3 3 0			
				44 10 7	
	Implements, ironmongery, &c.—				
35.	John Hannay	3 19 4			
36.	Alexander Thomson	3 3 2			
				7 2 6	
	Travelling expenses of forester and assistant—				
37.	John Baxter	19 11 5			
38.	George Gillian	11 4 1			
				30 15 6	
	Criminal prosecutions—				
39.	Walter Gregor	27 5 6			
				27 5 6	
	Keep of forest work-horse—				
40.	Robert Manfred	7 10 0			
41.	James Strachan	1 2 0			
42.	Thomas Low	11 9 6			
43.	James Shaw	6 8 6			
				26 10 0	
	Wages of carter—				
44.	James Parker	30 0 0			
				30 0 0	
	Saddlery—				
45.	George Yeats	4 3 6			
				4 3 6	
	Rates and taxes—				
46.	William Inglis, assessor	87 3 7			
				87 3 7	
				3468 14 1	
	1894.				
	Nov. 11.—By cash remitted to J. E. . .	4000 0 0			
	1895.				
	Nov. 20.—By do. do. do. . .	4000 0 0			
	„ 30.—By balance on hand, as per Bank-Book	740 15 9			
				8740 15 9	
				£12,209 9 10	

that the repairs of gates cost £4, 17s. more than was allowed for in the estimate; and that, on the whole, the fencing cost £60, 16s. 6d. less than was shown in the forecast at the beginning of the year.

That some difference, less or more, will occur in all such estimates must be expected by every judicious man; for it is not in the nature of things that, at the beginning of the year, when the works are merely in contemplation, the forester should know the exact sum that each is to cost. Such discrepancies, if within reasonable bounds, should therefore not be attributed to want of judgment in the forester, although on some particular works he may even be 15 per cent. wide of the estimate, provided that, on the whole, he come near to the truth.

As is shown with reference to this particular statement in question, the final result exhibited in the comparison of the actual and estimated expenditure is that, while an outlay of £3791, 14s. 10d. was approved and allowed for the estimates at the beginning of the year (see details on pages 435–437), they cost in all only £3784, 16s. 1d., or £6, 18s. 9d. less than was expected.

The advantage of keeping a book in which to register such a comparative statement with reference to each year's transactions must appear evident to every one who has paid any attention to the keeping of correct accounts of estate management. No proprietor ought to be without such a statement from his forester at the end of each year's transactions, as he can see at a glance from it whether or not his forester has realised the income he expected, and to what extent he has carried out the works he proposed at such a cost as he anticipated. Further, from having statements of this kind at hand, the proprietor can always look back upon them as guides to himself, and as a check on the forester when similar works are proposed for the future. But besides this, the keeping of such a book as has been here described will compel the forester himself to act with judgment in all he undertakes; for he of course knows that his employer will call him to account for any very great difference that may arise, whether with reference to income or expenditure. The next book, and the last one that need here be referred to, is that which shows the actual state of income and expenditure for the year. A specimen of this, based upon the copies of books and of statements already given, will be found on pages 468–471.

As exhibited in the statement there given, the sum of £12,209, 9s. 10d. is the gross amount which the forester is supposed to have received during the year; and for this amount, therefore, he has to account to his employer. It ought to be remarked here, however, that this amount of income is less than what was stated in the comparative statement (on page 463) by £316, 2s. The reason of this is that in the comparative statement the latter sum is entered in the actual statement of income as the value of plants supplied to the en-

closures from the nursery. This amount, however, was not actually received as payment by the forester; it was merely entered in the comparative statement in order to show the real value of the plants raised in the nursery, and planted out by him. But, deducting this sum of £316, 2s. from the gross revenue of £12,525, 11s. 10d., exhibited as the total income on page 463, there remains exactly £12,209, 9s. 10d. as the real, actual, or *nett income* for which the forester is supposed to have to account; and this corresponds exactly with the income exhibited in the statement given on page 463.

On the credit side of the statement, the different accounts are classified according to the details of the work they have been paid for; whilst, of course, the amount of all the vouchers for the different branches of accounts must correspond with the total of the sums paid out by the forester for the year, and as entered in his cash-book.

The first heading[1] of the accounts is for *Salaries and Allowances*, and for this there are nine vouchers in all. In making up this statement, the forester should write on the back of each voucher a number corresponding with that which he gives to it in the statement, so that he can at once lay his hand upon it from its distinctive number, independent of the description on its back. The amount exhibited as having been paid for salaries and allowances (£680), corresponds with that shown for the same heading on page 435.

The next heading in the system of classification of accounts is that of *Daily Labour and Piece-Work*, the vouchers of which are understood to be kept in the book called the Pay-List for Daily Labour and Piece-Work, a specimen page of which has been given facing page 444. In this statement are embraced all accounts paid for Fencing, Draining, Planting, Hedging, Repairs of Water-Runs, Sawmill Dams, Roads, &c.; Felling and Preparing Timber, Stripping and Curing Bark, Thinning, Clearing, and Burning Rubbish, Pruning, and all Nursery-Work—all, in fact, as detailed on pages 464–466 of the Comparative Statement of Expenditure.

[1] On large estates, where an extensive staff is kept up, it might be well to follow the method, prescribed in the Departmental Code of the Indian Forest Department, of classifying under *A.* all works of improvement, reproduction, utilisation, &c., and under *B.* the cost of establishments. The classification therein adopted, which may very easily be imitated so as to suit the requirements of large owners of woodlands in Britain, will be found on the two following pages.

This form is, of course, given merely for the sake of exhibiting all the classifications found expedient in a highly organised Department of Government, dealing with multitudinous forest products of the most varied description throughout all the provinces of a vast empire. It can, however, well serve as a model upon which to frame a very much simpler form of Budget specially adapted for all the home requirements of Britain.

REVENUE.

I. Timber and other Produce removed from the Forests by Government Agency—

(a) Timber	£
(b) Firewood and charcoal	
(c) Bamboos	
(d) Sandal-wood	
(e) Grass and other minor produce	

II. Timber and other Produce removed from the Forests by Consumers or Purchasers—

(a) Timber	
(b) Firewood and charcoal	
(c) Bamboos	
(d) Grazing and fodder grass	
(e) Other minor produce	

III. Confiscated Drift and Waif Wood	

IV. Revenue from Forests not managed by Government—

(a) Duty on foreign timber and other forest produce	
(b) Revenue from shared and private forests	

V. Miscellaneous—

(a) Fines and forfeitures	
(b) Refunds	
(c) Other sources	

Total	£

EXPENDITURE.

A.—CONSERVANCY AND WORKS.

	£
I. TIMBER AND OTHER PRODUCE REMOVED FROM THE FORESTS BY GOVERNMENT AGENCY—	
(*a*) Timber	
(*b*) Firewood and charcoal	
(*c*) Bamboos	
(*d*) Sandal-wood	
(*e*) Grass and other minor produce	
II. TIMBER AND OTHER PRODUCE REMOVED FROM THE FORESTS BY CONSUMERS OR PURCHASERS	
III. CONFISCATED DRIFT AND WAIF WOOD	
IV. REVENUE FROM FORESTS NOT MANAGED BY GOVERNMENT—	
(*a*) Duty on foreign timber and other forest produce	
(*b*) Revenue from shared and private forests	
V. RENT OF LEASED FORESTS AND PAYMENTS TO SHAREHOLDERS IN FORESTS MANAGED BY GOVERNMENT	
VI. LIVE STOCK, STORES, TOOLS, AND PLANT—	
(*a*) Purchase of cattle	
(*b*) Feed and keep of cattle	
(*c*) Purchase of stores, tools, and plant	
VII. COMMUNICATIONS AND BUILDINGS—	
(*a*) Roads and bridges	
(*b*) Buildings	
(*c*) Other works	
VIII. DEMARCATION, IMPROVEMENT, AND EXTENSION OF FORESTS—	
(*a*) Demarcation	
(*b*) Compensation for land and rights	
(*c*) Surveys and working plans	
(*d*) Sowing and planting	
(*e*) Protection from fire	
(*f*) Other works	
IX. MISCELLANEOUS—	
(*a*) Refunds	
(*b*) Law charges	
(*c*) Other charges	
Total *A.*—Conservancy and Works	£

B.—ESTABLISHMENT.

I. SALARIES—	
(*a*) Conservators	
(*b*) Superior officers	
(*c*) Subordinate forest and depôt establishments	
(*d*) Office establishments	
(*e*) Deputation and special allowances	
II. TRAVELLING ALLOWANCES—	
(*a*) Conservators	
(*b*) Superior officers	
(*c*) Subordinate forest and depôt establishments	
(*d*) Office establishments	
III. CONTINGENCIES—	
(*a*) Stationery	
(*b*) Carriage of tents and records	
(*c*) Rents, rates, and taxes	
(*d*) Pay of police-guards	
(*e*) Official postage	
(*f*) Sundries	
Total *B.*—Establishment	
GRAND TOTAL OF EXPENDITURE	£

All the other headings of accounts detailed in this statement explain themselves. They are simply different accounts paid by the forester during the year, then finally grouped together and arranged according to their special characters, and numbered for convenient reference.

From this statement it is shown that the forester, during the year, is supposed to account for and to exhibit vouchers as having paid out in all, for the different works, the sum of £3468, 14s. 1d.; that he has paid his employer at the dates mentioned £8000; and that he has on hand at the time he is supposed to render this account, £740, 15s. 9d. All these sums added together will duly correspond with the sum of £12,209, 9s. 10d., which is exhibited as the gross income on the debtor side of the statement; this, therefore, shows that the transactions have been correctly entered, otherwise the two totals would not tally.

The sum of £3468, 14s. 1d., stated as the gross sum expended by the forester during the year, will not be found to correspond with the sum brought out as the total expenditure in the comparative statement on pages 463–466. In the latter the sum of £316, 2s. is entered as the value of plants removed from the nursery; but this sum, as before stated, was not paid out by the forester, as it was merely entered in order to show the market value of the plants. Both statements, however, will be found to correspond by deducting the sum last named from the gross amount set down as the actual expenditure on pages 463–466. With this explanation, enough may have been said on the subject of book-keeping.

Every forester should, at the end of each year, render to his employer such a statement as has just been described, together with all the vouchers for the different accounts. On rendering it, he should also register a copy of it in a book retained for the purpose, so that he may at all times know what statement he has submitted, and may refer to any particular entry made in it, whenever occasion for such reference may arise.

With such a set of account-books as has been described above, any forester may keep his business accounts quite as clearly and intelligibly as a trained accountant could.

Two other books are also requisite, viz., the **Nursery-Book** and the **Bank-Book**. But the former is a mere register of the number of plants sent out and bought in; it is so simple that it may be kept in any form that the forester chooses to sketch out for himself. The latter, on the other hand, is a mere ordinary pass-book, kept between the banker and the depositor lodging the money; hence no further special reference need be made to it here.

APPENDIX.

FORESTS AND FORESTRY IN OTHER COUNTRIES THAN THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND.

I. The Forests of Continental Europe.—On the continent of Europe there is a very great variety of soil and climate. This area embraces plains and valleys of the richest character of soil, while there are hills and mountains having soils of the most varying nature.

In Spain, Portugal, Italy, France, Austria, and Turkey, all the indigenous trees of Europe, South Africa, North America, Southern Australia, and Northern and Central Asia find suitable conditions both as to soil and climate; while in Germany and throughout the southern parts of Russia, many of the kinds which luxuriate in the warmer countries named do not succeed, owing to the severity of the climate in the winter season.

In the cold regions of Northern Europe, embracing Norway, Sweden, and Russia, only the common sorts of trees grow well—such as the Norway Spruce, Scots Pine, Oak, Ash, Beech, Elm, Lime-tree, Alder, and Birch.

As the climate of Central and Southern Europe is considerably drier than that of Great Britain, this ensures a more thorough ripening of the young wood of foreign species than is generally attainable in England and Scotland; hence many exotic trees which succeed in the south of Europe do not live in the open air of Britain.

1. **Germany.**—Fully one-fourth of the whole extent of the German empire is occupied by woods and forests. The chief indigenous trees of this part are Oak, Larch, Beech, Firs, and Pines, with Alder, Elm, Lime, Birch, Ash, and Poplar. It appears that the ligneous plants of Germany embrace those of Great Britain along with her own. The forests in some parts are of great extent, and are very valuable, first-rate timber of the trees above mentioned being procured from them. The introduction of forest-trees has been varied and extensive, and very fine specimens of different foreign trees are now common in many parts of the country.

"North Germany possesses extensive forests on the Harz and Thuringian mountains, in East Prussia, the Odenwald in Hesse, the Westerwald and Taunus range in Nassau, and the Vosges. The chief trees are *Pinus sylvestris*, L., the 'Kiefer,' 'Weissföhre,' 'Gemeine Föhre,' and *Picea excelsa*, 'Fichte,' 'Rothtanne.' The Silver Fir (*Abies pectinata*, DC.: 'Edeltanne,' 'Weistanne') is abundant in the Vosges and in the Black Forest of Baden and Würtemburg, where we also have birch, 'Birke;' beech, 'Rothbuche;' and oak, 'Eiche;' whilst in Bavaria the larch, 'Gemeine Lärche,' is extensively grown. In the Spessartwald, near Aschaffenburg, there are large masses of oak and extensive coniferous plantations, more than a quarter of the area of Bavaria being under wood, much of it being mountainous, and there being a large demand for fuel. No less than 23 per cent. of the area of the kingdom of Prussia is forest land. The chief trees in the province of Prussia are the 'Kiefer' (*Pinus sylvestris*, L.) and 'Fichte' (*Picea excelsa*), which comprise three-fourths of the whole. 'Lärche' (*Larix europæa*, DC.) is rare. 'Buchen' (*Fagus sylvatica*, L.), 'Hainbuchen' or 'Weissbuchen' (*Carpinus Betulus*, L.), 'Eiche' (*Quercus*), 'Spitzahorn' (*Acer platanoides*, L.), 'Bergahorn' (*A. Pseudo-platanus*, L.), 'Ruster' (*Ulmus campestris*, Spach.), 'Erle' (*Alnus glutinosa*, Gaertn.), 'Birke' (*Betula alba*, L.), 'Sahlweide' (*Salix Caprea*, L.), 'Werftweide' (*S. acuminata*, Sm.), 'Linde' (*Tilia europæa*, L.), 'Eberesche' (*Pyrus Aucuparia*, L.), and 'Aspe' (*Popula tremula*, L.) also occur.

"Similar trees occur in Posen and Pomerania, 'Hasel' (*Corylus Avellana*) being also grown in the latter province. 'Edeltanne' (*Abies pectinata*, DC.) is recorded for Silesia, and the 'Weymouthskiefer' (*Pinus Strobus*, L.) and 'Esche' (*Fraxinus excelsior*, L.) also for Brandenburg. The 'Faulbaum' (*Rhamnus Frangula*) and 'Eibe' (*Taxus baccata*, L.) are among the chief trees of the province of Saxony, and the 'Pappel' (*Populus*), 'Weissfichte' (*Abies pectinata*), and 'Zwergkiefer' (*Pinus Pumilio*) among those of Schleswig-Holstein; otherwise the lists from the various provinces are similar to the above. Oak is largely used for artillery purposes, and Aspen and Birch in shipbuilding. By the Budget for 1880, 50,000 marks were assigned for the introduction of foreign trees, including *Pinus Laricio*, 'Schwarzkiefer,' from South Europe; *Abies Nordmanniana*, from the Caucasus; *Picea sitchensis*, from Japan, together with some other Conifers; and the following species from North America:—

Pinus rigida, *ponderosa*, and *Jeffreyi*.
Abies (*Pseudotsuga*) *Douglasii*.
Thuja gigantea.
Cupressus Lawsoniana.
Juniperus virginiana.
Carya alba, *amara*, *aquatica*, *porcina*, and *tomentosa*.
Juglans nigra.
Quercus rubra.
Betula lenta.
Populus monilifera.
Acer Negundo, *saccharinum*, and *dasycarpum*.

"The Duchy of Gotha contains 44,140 hectares of forest, 85 per cent. of which is Pine, the chief other trees being Beech, Spruce, Larch, Oak, Maple, Ash, Birch, and Elm. Coburg contains 15,718 hectares of similar forests.

"The Kingdom of Saxony includes about 465,000 hectares of timber land, the chief species being *Quercus sessiliflora*, Sm., 'Traubeneiche, Steineiche,' *Fagus sylvatica*, *Fraxinus excelsior*, *Betula alba*, *Alnus glutinosa*, *Picea excelsa*, *Pinus sylvestris*, *Abies pectinata*, and *Larix europæa*.

"Hesse-Darmstadt includes about 168,000 acres, and Baden nearly

1,270,000 acres of forest; *Pinus sylvestris*, *P. Strobus*, *Picea excelsa* and *Abies pectinata*, and *Larix europæa*, being the prevailing conifers. Hessian Fir-trees are in great demand in Holland for shipbuilding.

"The Kingdom of Würtemburg includes 596,000 hectares, or over 30 per cent. of its area, of forest, comprising the Pine-wood districts of the Black Forest, Upper Swabia, and the Jaxt Circle; and the hardwood forests of the Swabian Alps and of the 'Unterland.' The Spruce, Silver Fir, and Scots Fir are the chief conifers, and are mostly used as timber, much being floated down the Rhine. Spruce-bark is mixed with that of the Oak in tanning, and the chopped branches are used as litter. Oak, of which both *Quercus pedunculata*, Ehrh., 'Stieleiche, Sommereiche,' and *Q. sessiliflora*, Sm., occur, is largely in demand for shipbuilding in Holland, and for general purposes at home. Beech is the chief fuel, but is also used for ships' keels, by carriage-builders, and by chairmakers. Ash, Hornbeam, Elm, Linden, Birch, Alder, and Maples (*Acer campestre*, L., 'Feldahorn;' *A. platanoides*, L.; and *A. Pseudo-platanus*, L.), are also used in carriage-building, turnery, &c., and as fuel; whilst Aspen is in demand for paper and match manufacture" (Boulger, *Economic Forestry*, in *Trans. Scot. Arbor. Socy.*, vol. xi., part iii., 1887, p. 388).

2. **France.**—The woodlands of France are said to embrace nearly 18 per cent. of its whole area. From this country being so situated as to command the most temperate climate and some of the highest hills in Europe, it is said to contain the richest and most varied kinds of ligneous plants in any European country. All of the timber-trees which are indigenous to Britain are also indigenous to France. The chief timber-trees are the Oak, Ash, Elm, Firs, and Pines, with Lombardy Poplar, Sweet Chestnut, Sycamore, Alder, Lime, Beech, and in some parts magnificent Birch. The French, like ourselves, have done much to forward the art of forestry in their country by the introduction of foreign trees; and consequently fine specimens of trees from nearly all parts of the world are to be seen in the arboreta scattered throughout different parts of the country.

"Though having forests in almost every Department, covering in all about one-seventh of her area, France imports large quantities of common woods, as well as the more valuable exotic kinds.

"The principal timber trees of France are Oaks, 'Chênes,' of which *Quercus Robur*, L.; *Q. apennina*, Lam.; *Q. lanuginosa*, Th.; *Q. Toza*, Bosc.; *Q. Cerris*, L.; *Q. Pseudo-suber*, Sant.; *Q. Ilex*, L.; *Q. Suber*, L.; *Q. occidentalis*, Gay; *Q. coccifera*, L.; and *Q. pseudo-coccifera*, Dsf., are indigenous. *Q. Suber* and *Q. occidentalis* are considerably cultivated in the south and in Corsica. The latter does not ripen its acorns until the second year. Cork is stripped from *Q. Suber* after twelve or fifteen years' growth, and then at intervals of from seven to ten years; but the two first gatherings are useless for 'corks.' Beech ('Hêtre'), Ash ('Frêne'), Elm ('Orme'), Sycamore ('Fauxplatane'), and other Maples ('Erables'), Birch ('Bouleau'), Walnut ('Noyer'), and the Lombardy Poplar (*Populus fastigiata*), are important deciduous trees; the Silver Fir and Spruce ('Sapin Rouge') are abundant in the Vosges and Jura mountains; and *Pinus halepensis*, Mill., the Aleppo Pine, and *P. Pinaster*, Soland ap. Aiton, the Maritime or Cluster

Pine (*P. maritima*, Poiret apud Lam.), are indigenous, and much cultivated in the south. The Spruce yields 'Burgundy pitch' and 'frankincense;' whilst 'Bordeaux turpentine' is obtained by cutting long slips off the stem of the Cluster Pine, with which the dunes of the south-west coast have since 1789 been so successfully planted" (Boulger, *op. cit.*, p. 392).

3. Russia in Europe.—This empire is said to have about 36 per cent. of the whole area occupied by woods and forests. In the northern parts occur the Scots Pine, Norway Spruce, Common Birch, Alder, Aspen, Willows of different kinds, Maple, Lime-tree, Beech, Elm, and Oak, &c.; while the south abounds in the species indigenous to warmer climates. Many kinds of trees are to be found in Russia which are not indigenous to Britain. The introduction of foreign trees into Russia has not been attended with very marked success, owing to the severity of the climate in winter. The forests, in some places, luxuriate in large unbroken tracts of country, quite undisturbed since they came from the hands of nature.

"With by far the largest forest area of any European country (469½ million acres), both absolutely and relatively to its entire extent, Russia is very unequally wooded. Two-thirds of her forests are in the north-east; in the north-west they form from 30 to 50 per cent. of the whole area; in the central and western districts 27 per cent.; in the south-west 2·5 per cent.; and in Little Russia only ·7 per cent. The Spruce is the prevalent tree in the north, the Siberian Larch (*Larix sibirica*, Led.) in the north-east, whilst *Pinus sylvestris*, L., has a very wide range in latitude, flourishing in the Caucasus (41½ deg. N. lat.) and Crimea, as well as on the shores of the Baltic. A variety, *P. Frieseana*, Wich., extends farther north in Lapland, Finland, and Sweden. Birch is abundant, and in the central and southern districts Oak, Beech, Ash, Lime, Walnut, and Box. Besides an enormous home consumption for fuel and building, Russia exports coniferous wood largely from Archangel and the Baltic ports, about 7000 tons of tar per annum, paper pulp from the Aspen, large quantities of 'Russia matting,' the 'bast,' or inner bark of the Linden (Russian 'Lipa'), *Tilia europæa*, L., and boxwood from the Caucasus. The latter is brought to England in billets from 3 to 8 ft. long, and from 3 to 18 in. in diameter, fetching from £4 to £15 per ton. The Corsican Pine (*P. Laricio*) is extensively planted in the Crimea; and while Beech and Scots Fir occur on the northern slopes of the Caucasus, on the south side we have *Abies orientalis*, Led., *Abies Nordmanniana*, *Pterocarya caucasia* (nat. order, *Corylaceæ*), introduced into England about 1830, and *Zelkova crenata*, Spach., a heavy, hard, reddish wood at heart, with a lighter and elastic sapwood, similar to its ally the Elm (nat. order, *Ulmaceæ*). It takes a good polish, and is used for furniture.

"Other important species are the 'Cedar' (*Pinus Cembra*, L.), forming large forests in Perm and Volgoda, the Aspen, the Hornbeam (*Carpinus Betulus*), distinguished as 'White Beech' from *Fagus sylvatica*, the 'Red Beech,' and forming whole forests near Kieff and Poltava, the Alder (*Alnus incana*), and the European Larch (*Larix europæa*) in Poland. Of the total timber output for 1880 from Government forests of over 2,900,000 cubic fathoms, Spruce constituted 37·5 per cent., Pine 27·8, soft woods (Birch, Lime, Aspen, &c.) 19·5, and hard woods (Oak, Beech, &c.) 8·8 per cent.

Walnut and Boxwood form articles of export. Plantations have been made along several railways to protect them from snowdrifts, and *Pinus Pinaster* has been used, with smaller plants, on the sand-plains at Aleschki, on the Dnieper" (Boulger, *op. cit.*, p. 391).

4. **Austria.**—Next to Germany, Forestry is more scientifically practised in Austria than in any other country in Europe.

"The forests of the Austrian Empire occupy 66,600 English square miles, those of Austria being more than 30 per cent. of its whole area, and those of Hungary 26·6 per cent. They are situated mainly in the mountain regions of the Carpathians, Transylvania, Galicia, Bohemia, the Alps, Croatia, and Slavonia. Spruce, Silver Fir, Larch; *Pinus montana*, Duroi; *P. sylvestris*, and *P. nigricans*, Host. (= *P. austriaca*, Höss.), are the prevailing species; but Beech, several species of Oak, including *Q. Robur*, L.; *Q. lanuginosa*, Th.; and *Q. Cerris*, L., with Elm (*Ulmus campestris* and *U. effusa*); Poplar; Chestnut, 'Edelkastanie;' and Walnut, 'Wallnussbaum,' occur at lower altitudes, especially in the south. Dalmatia and Croatia come within the Mediterranean area, and have also *Quercus Pseudosuber*, Sant.; *Q. Ilex*, L.; and *Q. coccifera*, L., together with the Olive, Mulberry, and Fig (*Ficus Carica*, L.). These are mostly cultivated, as is also the Corsican Pine,[1] *Pinus Laricio*, Poir., which is nearly allied to the Black Austrian Pine (*P. nigricans*). The timber is used mainly for fuel and building purposes; but in addition to 67,000,000 cubic ft. of timber, the forests are estimated to yield 4,000,000 cwts. of bark (Larch and Oak) for tanning, 500,000 cwts. of gall-nuts, 250,000 cwts. of turpentine and resin, and 100,000 cwts. of potash annually. The turpentine of the Larch is known, from its port of shipment, as 'Venice turpentine;' that from the Silver Fir as 'Strasburg turpentine'" (Boulger, *op. cit.*, p. 390).

5. **Switzerland.**—The trees native or indigenous to this country are numerous, as in Switzerland arctic conditions prevail upon its highest mountains, with much warmer climates in the valleys. This little country consequently contains many kinds of native trees which are not indigenous to Britain. The more common and useful trees are, however, the Elm, Oak, Birch, Alder, Olive, and various coniferæ, including the European Larch, together with Lombardy Poplar, Sweet Chestnut, and Sycamore. The introductions of foreign trees to this country have been varied and extensive.

"With one-sixth of its whole area under forest, Switzerland presents a characteristically mountain flora. Its chief timber-trees are *Picea excelsa*, DC. (= *Pinus abies*, L.), used for planks, building, firewood, and charcoal; *Abies pectinata*, which reaches altitudes of 4000 ft., similarly employed; *Pinus sylvestris*, L., preferred to the two former as fuel; *P. Cembra*, L., 'Arve' or 'Zirbelkiefer,' a white, worm-resisting wood, esteemed for milk-tubs and for flooring; *Larix europæa*, DC., extending to an altitude of 3000 ft., used for sleepers; *Quercus Robur*, L., *Q. pedunculata*, Ehrh., and *Juglans regia*, L., extending to 1800 ft., but not abundant; *Fagus sylvatica*, L., up to 3000 ft., the best wood for fuel and charcoal: Maples, Ash, Birch, Hornbeam, Alder, and Aspen" (Boulger, *op. cit.*, p. 394).

[1] Pine-wool and Pine-oil are prepared from the Corsican Pine.

6. Norway and Sweden.—These countries have respectively about 44 and 24 per cent. of their surface occupied by forests. The principal useful timber-trees indigenous to the country are the Norway Spruce, Norway Maple, Scots Pine, Elm, Beech, Ash, Birch, Lime, Willow, and Alder. An extensive trade is carried on between these countries and Great Britain in the export of the timber of the Spruce and Pine. In the inland parts of the country, and especially in the north, there are immense tracts of unbroken forests of old timber. The most accessible parts are being rapidly cleared of the marketable crops, but young wood is growing up in their place. The attempts at the introduction of foreign trees suitable for temperate climates have attained considerable success here; consequently Oaks, Poplars, foreign Pines, Walnuts, and other trees are now to be found growing to fair dimensions of timber in the plantations of the country.

"The chief forests of Norway are in the east, and consist of Scots Fir, Spruce, and Birch. Of 80,000,000 cubic feet annually exported, more than half is sent to the United Kingdom. The Norway Spruce (*Picea excelsa*, Link.) is common to all the mountain ranges of Europe, to the Arctic Circle, reaching 150 or even 180 feet in height, and more than 15 inches in diameter. Its wood, known as 'white deal,' or 'whitewood,' is used for ladders, scaffolds, sounding-boards, sabots, and gunpowder charcoal. In the forest nurseries of Stavanger, the chief trees cultivated are Scots Fir, Spruce, and Willow (*Salix lanceolata*, Sm.), the latter species, introduced from the Netherlands, being used for hoops. The average export of timber from Norway between 1861 and 1882 was between 800,000 and 900,000 tons.

"Scots Fir and Spruce form also the staple of the forests in Sweden, the greater portion of which are in the northern and central provinces. The river Dal forms the northern limit of the Oak and Beech in a wild state; but they are cultivated in much higher latitudes. The White Birch (*Betula alba*, L.) is found in profusion throughout the kingdom, being chiefly used for firewood, but locally for furniture, agricultural implements, &c. The Aspen (*Populus tremula*, L.), which is also common, is used in the manufacture of matches and of paper pulp. The former manufacture yielded £225,000 in 1872, of which £168,000 worth were exported. Paper pulp is made also from Pine-wood. It was first exported in 1872, when nearly all (to the value of £55,000) came to Great Britain. Alder, Elm, and Lime are also common, and attain a large size in the more favoured districts. The Pine-wood is used in house and ship building; and both as pit props and in a manufactured form, as window and door frames, &c., constitutes a chief article of export, an increasing quantity annually reaching Great Britain" (Boulger, *op. cit.*, p. 387).

7. Italy.—The extent of woodland here is about 12 per cent. of the whole area. The more important timber-trees common in the woods are various species of the Oak, Poplar, Pine, and Fir, with Walnut, Plane-tree, and Chestnut. The introduction of exotic trees and shrubs from all parts of the world has occupied the attention of the Italians since the fifteenth century; consequently fine specimens

of some of these are now quite common in the south of Italy. The geniality of the climate of this country is very well known; hence the success of the introduction of foreign trees can easily be accounted for. Italy now possesses, by means of introduction, nearly all the trees of Australia; and, as is also the case in Spain, it is considered that the ligneous plants of all the world might be cultivated with success here. In the south, from the equable and genial character of her climate, Italy is quite capable of growing species from tropical climes; while among the rugged and cold hills of the Apennines the hardy trees of arctic regions will luxuriate as in their native situations.

"With only about 12 per cent. of its area under forest, Italy, owing to the Apennine range, presents a great diversity in its flora. *Pinus Pinea*, L., the 'Stone Pine,' the seeds of which are eaten, and which once formed the beautiful forest of Ravenna; and the Olive (*Olea europæa*, L.), the fruit and oil of which form one of the chief products of the country, are the two most characteristic trees. The wood of the latter, used for ornamental purposes, is very beautiful. The slopes of the Alps and Apennines are clothed with Chestnut and Silver Fir, *Pinus halepensis*, the Manna or Flowering Ash (*Fraxinus Ornus*, L.; nat. order, *Oleaceæ*), Mulberry, Beech, Larch, and a variety of Oaks, are also common. The Mulberry (*Morus alba*, L.) is grown chiefly as food for the silkworm. Among the Oaks are enumerated *Quercus Robur*, L.; *Q. Ilex*, L., the 'Holm' Oak; *Q. montella*, *Q. pyrenaica*, *Q. Æsculus*, L.; *Q. Cerris*, L.; *Q. Pseudo-suber*, Sant.; *Q. Suber*, L.; *Q. pseudo-coccifera*, Dsf.; and *Q. coccifera*, L., besides other forms not generally admitted as species. [See Laslett, pp. 43–76.] The Service and White Beam are used as in France, and, in addition to the Laburnum, the hard wood of the Judas-tree (*Cercis Siliquastrum*, L.; nat. order, *Leguminosæ*) is also indigenous. Besides the Sycamore (*Acer obtusatum*, Kit.), which ranges into Hungary, and reaches 40 to 60 ft., also occurs; but *A. platanoides*, L. ('Acero riccio'), from which sugar can be prepared, is found only in the mountains" (Boulger, *op. cit.*, p. 394).

8. Spain and Portugal.—These countries have respectively about 17 and 5 per cent. of their whole area under forests.

The prominent timber-trees in the woods of Spain and Portugal are the sessile-fruited Oak, Turkey Oak with its varieties, Evergreen Oak with numerous varieties, the Cork Oak, Stone Pine, and Scots Pine, with Lombardy Poplars, Sweet Chestnut, Sycamore, and Birch. The Silver Fir is sometimes met with, as also the Larch on the higher mountain-ranges of the north. The country is well adapted for the introduction of exotic trees. This branch of arboriculture has gained the attention of the Spaniards since the days of communication with foreign countries began; and it is even stated that specimens of all the well-known ligneous plants of the world have been seen growing successfully in one or other of the botanic gardens of Spain. The list of indigenous trees of this country is, at the same time, very considerable.

"The Iberian peninsula is deficient in forest; but on the north coast there is much *Pinus Pinaster*, and on the Pyrenees, *P. Laricio*, *P. pyrenaica*, and *P. halepensis* occur, which, south of Lisbon, are replaced by *P. Pinea*, and on the limestone mountains of Grenada by *Abies Pinsapo*, Boiss. The Chestnut, the Holm Oak, and the Cork Oak, are the chief broad-leaved trees of the Peninsula, the former being cultivated, as in Italy and Sicily, for its fruit" (Boulger, *op. cit.*, p. 395).

9. The Netherlands.—The woodlands here extend to about 7 per cent. of the entire area. The natural timber productions of these parts of Europe are of small importance, although very fine specimens of several importations are numerous, especially from America. The catalogues of the botanic gardens of Leyden show that the introduction of foreign trees and shrubs occupied the attention of arboriculturists there at as early a date as was the case in any other country in Europe.

"There are no indigenous forests in Holland; but Beech, Poplar, Willow, Ash, and Elm are much planted. *Ulmus major*, L., the Dutch or Sand Elm, was introduced into England from Holland, and the exportation of Alder Buckthorn has been already noted. The sand dunes are extensively planted with conifers" (Boulger, *op. cit.*, p. 388).

10. Denmark.—The forests of this country cover about 5½ per cent. of the whole area. The woods are made up chiefly of Beech, White Poplar, Scots Pine, Oak, and Norway Spruce. A considerable number of exotic trees has been introduced into this country; but these are to be found chiefly in the botanic gardens, and in the parks of landed proprietors.

"There are extensive forests of Beech, the chief indigenous trees besides being Spruce, Scots Fir, Birch, Aspen, and Oak. The wood of the Scots Fir is known as redwood, or red deal, as distinguished from the whitewood of the Spruce, but some varieties yield 'yellow deal.' The chief Oak forests are on the islands of Falster and Lolland. Plantations of the Swiss *Pinus montana*, Duroi, the American *Picea alba*, the Norway Spruce (*P. excelsa*, Lam.), and the Silver Fir (*Abies pectinata*, DC.), have been extensively carried out in West Jutland" (Boulger, *op. cit.*, p. 388).

11. Belgium.—In this portion of Europe the land under woods is 16½ per cent. of the whole area. The indigenous trees of Belgium are comparatively few, owing to the similarity of the conditions of the soil and climate over all, and partly to the very limited extent of the country embraced.

"There are extensive forests in Brabant, Flanders, and the Ardennes, the latter largely consisting of Beech" (Boulger, *op. cit.*, p. 388).

12. Turkey and Greece.—Although the latter country is not of much importance as regards its forests and timber productions, yet those of the former are of considerable extent and value (see vol. i. p. 12). The trees most common about Constantinople are the

Turkey Oak, Pinaster, Stone Pine, European Nettle-tree, European Judas-tree, Evergreen Cypress, the Wild Olive, Carob-tree, European Date-Palm, Turpentine-tree, the Smilax-tree, the Common Ivy, the Cherry-tree, the Plane-tree. The Minorca Box-tree grows in wild profusion on all the rocky surfaces of the country, and is largely exported to Great Britain for engraving purposes.

"Roumania produces Oak, Walnut, Beech, Yew, Silver Fir, and Spruce. *Quercus Cerris*, L., the Turkey Oak, is very characteristic of the Balkan Peninsula, as is also the Horse Chestnut and the Macedonian *Pinus Peuce*" (Boulger, *op. cit.*, p. 392).

Conditions of Forestry throughout Continental Europe.—In Germany, Austria, and France—but more particularly in the first-named country—forestry is well understood, and is put into practice in a very thorough and systematic way. The Governments of these countries take the lead with respect to management of woods, and in carrying out efficient schemes of forest economy—both for the welfare of the community at large and as an example to the landed proprietors.

A large portion of the woodlands of these countries is occupied by coppice-growths, which are used largely as fuel and for many other economic purposes; while extensive forests, and smaller plantations of timber, exist of all the kinds of trees indigenous to the Continent. Large experiments are at the same time being made with such exotic species as hold out fair promise of yielding good agricultural returns.

Nearly all the proprietors of woods in these countries manage their crops by means of **annual falls**. That is to say, if the crops on any portion of, or block of woods on, an estate are found to come to maturity at, say, fifty years of age, then they are divided into fifty equal or equivalent portions, and one portion (that which is mature) is cut each year, so that a fairly constant supply of timber may be had. The crop of the division cut the first year is again ready for disposal in the fifty-first year after; and in the same way all the other divisions follow for disposal in their order. If the crops on any part are found to require eighty or a hundred years to come to full value, then they are divided accordingly, and the oldest portion cut each year successively; hence a sustained yield or continuous annual supply of wood is kept up on any property, without the crops on it being lessened either in extent or value.

In the case of woods like Oak, Beech, Silver Fir, &c., which are usually regenerated naturally, then several annual falls are grouped together and treated as a unit. Say, for example, that the period of reproduction is estimated at about ten years; then ten annual falls would be grouped into one periodic fall, and within this period of ten years the whole of the **preparatory fellings**, **seed fellings**, and **gradual clearances** (see vol. i., chap. vii. p. 560) would be carried out as forecast in the working plan.

The statement made in the last paragraph refers to the general mode of dealing with timber plantations on the Continent of Europe. It may here be remarked that, with regard to coppice woods, these are dealt with in a similar way; but they are, of course, cut down at shorter intervals, say of from fifteen to twenty-five years, according to the object in view with regard to the disposal of the produce. If the coppice-growths can be profitably disposed of when of twenty years of age, then the whole of this sort of woodland crop is divided, as nearly as possible, into twenty equal or equally productive portions, and one compartment is cut and disposed of each year, taking each portion in its order as to age. In this way a sustained yield or continuous supply of this class of produce is kept up on any estate.

In the case of **clear fellings** or **total clearances** of timber crops, as often occurs in the case of Scots Pine, Spruce, and Larch, the re-planting of the land of each portion after it has been cleared of its crop is skilfully attended to in the forest economy of the countries under notice. The officers in charge of the forests are all well trained in scientific forestry, and their subordinates are experienced in sylviculture; hence due attention is given in order to adapt the various kinds of trees to the soil and situation best suited to them on each portion. In this respect they certainly show in their practical work a much more extensive knowledge of the natural habits and peculiarities of the trees they cultivate than can be claimed by foresters in Britain.

In renewing the crops on the cleared portions of land, as these come to be dealt with each year, advantage is taken of the spontaneous growths, or young seedling trees, that have come up on them; and, if considered judicious, seeds of the different kinds of trees it is wished to rear on them are sown on unoccupied spots. Planting with young trees is undertaken only on such parts of the land as may be found unsuitable for the renewal of the crop by sowing the seeds.

When the woods are treated by the method of **natural regeneration**, the parent crop of mature standards is not removed till the bulk of the area has a crop of seedling growth. Any blanks that then exist can advantageously be filled up by sowing or planting; and at the same time the opportunity is thus given of forming mixed woods by the introduction of other kinds of trees than those which have been made to reproduce themselves naturally by seed.

As the young crops make progress, thinning is attended to. But in this branch of arboriculture the author is of opinion that the French, Austrians, and Germans are defective. Generally speaking, their crops are kept in what may be termed a crowded condition, whereby the trees are grown too tall in proportion to their diameter of stem; and thus their respective crops are prevented from becoming so valuable as they are capable of doing were they more liberally thinned.

The editor's opinion is totally at variance with the author's on this point. The want of knowledge with regard to the normal density of woods is one of the worst features of British forestry (see vol. i., pp. 14 and 582).

Throughout the other countries of Europe, systematic forestry has not generally been so well attended to as in the countries just referred to. In most of the other divisions of the Continent of Europe, however, the German mode of forestry is being put into practice, and is fast gaining ground upon the old haphazard way of clearing here and planting there which has prevailed hitherto. This introduction of method and regularity must be vastly to the advantage of the landholders themselves, as well as to the States of which the woodlands form a part.

Portugal seems likely ere long to take a leading part in the arboriculture of the Continent of Europe. For some years past the Department of Woods and Forests of that country has been planting, experimentally, all the kinds of newer coniferæ, with a view to ascertain their suitability for producing useful timber in Portugal. This fact is worthy of being recorded here, as indicating a commendable spirit of improvement in the right direction; for there can be no doubt that an increase in the forest area will conduce to the future welfare of Portugal.

II. The Forests of America.[1]—**1. Canada.**—In referring to Canada, the author means to include the whole of British America, from the Atlantic to the Pacific. Here there is a great variety of soil and climate; but, owing to this portion of North America lying to the north of the United States, its climate is colder, and therefore less suited to the growth of many foreign trees.

On the Pacific slope, and especially in British Columbia, there are vast forests of native trees—particularly of *Pseudotsuga Douglasii*, *Cupressus nutkaensis*, *Sequoia sempervirens*, and various species of *Picea* and *Abies*—showing that the soil and climate of this portion of Canada are as suitable to the growth of these fine trees as are the conditions obtaining in Northern California. British Columbia may therefore be said to be well suited to the growth of many trees native to foreign countries, especially of those from Europe and Northern Asia, and of those from the northern States adjoining on the south.

All the country stretching from the Rocky Mountains eastward to Hudson's Bay and the Ottawa River, and northward to the 60th degree of latitude, is well adapted, as regards both soil and climate,

[1] Further information may be obtained with reference to the forests of America from an article in the *Journal of the Society of Arts* for February 1893. But see also vol. i., chap. i., p. 79 of this work.

to the healthy growth of all the trees indigenous to North America, from the 40th degree of latitude.

As a proof of the soil and climate of Canada being excellently suited to the healthy development of most of the timber-trees of Europe, it may be mentioned that the European Larch grows fully better there than it does in Great Britain, and that it attains a larger bulk of timber within a given time; while the Scots Pine, the Austrian Pine, and the Norway Spruce thrive equally well. Many of the hard-wooded trees indigenous to Europe also prosper well in Canada; as, for example, the Common Sycamore, the Norway Maple, the Horse Chestnut, and many others.

To the east of the river Ottawa the climate is colder than in the parts above referred to. It is therefore best adapted for indigenous species only, although some of the hardier kinds of European trees succeed well.

The existing natural forests of Canada afford unmistakable proof of the suitability of the soil and climate of the country for the growth of trees. Probably no country in the world has a greater bulk of timber per acre than is to be found in Canada.

"**Prince Edward's Island.**—In 1874 the forests of Prince Edward's Island occupied one-eighth of its area (2173 square miles), but were rapidly decreasing from fires, clearing, &c., much 'Cedar' (*Juniperus virginiana*) having been cut for railway purposes and other soft woods for building. Among the species are also White and Black Spruce (*Picea alba* and *P. nigra*), various varieties, 'red,' 'white,' and 'black,' of the 'Hemlock' (*Tsuga canadensis*), 'White Birch' (*Betula papyracea*) and 'Yellow Birch' (*B. lenta*). 'Rock Maple' (*Acer saccharinum ?*) and 'White Maple' (*A. dasycarpum ?*), besides Beech, Hazel, Oak, Elm, Ash, Pine, and Fir.

"**Nova Scotia.**—Nova Scotia was computed to contain nine million acres of timber land in 1875. The strongest and most durable timber is that of the Larch or 'Hackmatac' (*Larix americana*), whilst next in utility rank the 'white,' 'hard,' 'pitch' or 'Norway Pine' (*Pinus Strobus*, L.) and Hemlock. Besides these there are:—'Balsam' or 'Silver Fir' (*Picea balsamifera*); 'white' and 'black' or 'double Spruce;' 'mountain Pine' (*Pinus Pinea*, L.); 'black' or 'yellow Birch' (*Betula lutea*, Michx. ?), 'white,' 'canoe,' or 'paper Birch' (*B. papyracea*, Aiton), and 'dwarf,' 'mountain' or 'river Birch' (*B. lenta*, L. ?); 'sugar,' 'rock,' or 'bird's-eye Maple' (*Acer saccharinum*, Wang.), 'red,' 'flowering,' 'scarlet,' or 'swamp Maple' (*A. rubrum*, L.), 'mountain' or 'dwarf Maple' (*A. spicatum*, Lamk.), and 'striped Maple' or 'Moose-wood' (*A. striatum*, Lamk., or *A. pennsylvanicum*, L. ?); Beech (*Fagus sylvatica*, L.); Elm (*Ulmus americana*, L.); Hornbeam (*Ostrya virginica*, Willd.); 'red Oak' (*Quercus rubra*, L.); 'white' and 'black Ash' (*Fraxinus americana*, L., and *F. sambucifolia*, Lamk.); 'choke,' 'red,' and 'black' or 'pigeon Cherry' (*Prunus virginiana*, L. = *P. borealis ?*, *P. pennsylvanica*, L., and *P. serotina*, Ehrh.), the latter extensively used in cabinet-work; and various Poplars, including *Populus tremuloides*, Michx., and *P. grandidentata*, Michx., used for paper pulp.

"**New Brunswick.**—The timber-producing lands of New Brunswick in 1874 were estimated at six million acres, mainly covered with hard woods

such as Beech, of which there are two varieties, the 'red' (*Fagus ferruginea*, Aiton) and the 'white' (*F. sylvatica*, L.), the former the more valuable; 'black,' 'yellow,' 'white,' and 'paper Birch;' 'rock Maple' (*Acer saccharinum*, Wang.), &c.; 'white,' 'red,' and 'Prince's Pine' (*Pinus Strobus*, L., *P. resinosa*, Aiton, and *P. Banksiana*, Lambert); 'white' and 'red Elm' (*Ulmus americana*, L., and *U. fulva*, Michx.); 'Butternut' (*Juglans cinerea*, L.); 'white,' 'black,' and 'red Ash' (*Fraxinus americana*, L., *F. sambucifolia*, Lamk., and *F. pubescens*, Lamk.); 'yellow Ash;' 'Aspen' and 'balsam Poplar' (*Populus tremuloïdes*, Michx., and *P. angustifolia*, James?); 'Basswood' (*Tilia americana*, L.); 'Ironbeam' (*Ostrya virginica*, Willd.?) and 'Hornbeam' (*Carpinus americana*, Michx.) occurring in considerable quantities; and Oak, chiefly *Quercus rubra*, L., in small quantities. Black Spruce furnishes most of the deals exported, though the white and balsam Spruces are also used. 'Hackmatac' or 'Tamarac' (*Larix americana*, Michx.), 'Cedar' (*Cupressus thyoides*, L.), and Hemlock (*Tsuga canadensis*, Carr.) are among the most valuable timber-trees in the provinces, Cedar sleepers and Hemlock bark-extract being considerable articles of export.

"**Quebec.**—Of nearly seventy-four million acres of forest in the province of Quebec in 1874, fifty-five and a half belonged to Government; but the clearing has long been excessive. The species are mostly the same as those of New Brunswick, the commonest species being 'white Pine' (*Pinus Strobus*, L.), 'yellow Pine' (*P. mitis*, Michx.), 'red Pine' (*P. resinosa*, Aiton), 'white Cedar' (*Thuja occidentalis*, L.), 'hard Maple' (*Acer saccharinum*, Wang.), white and black Spruce, Tamarac, and white Elm. The white Oak (*Quercus alba*, L.), the only species in the province, is comparatively scarce.

"**Ontario.**—The timber trade forms the chief industry of the province of Ontario, 87 per cent. of the amount felled being exported. White and red Pine, black and white Spruce, 'white' and 'red Cedar' (*Thuja occidentalis*, L., and *Juniperus virginiana*, Lawson), Elm (*Ulmus fulva*, Michx.), and Birch are the only abundant woods.

"**British Columbia.**—Two-thirds of British Columbia, or about 110 million acres, almost entirely under Government control, was, in 1874, under timber" (Boulger, *op. cit.*, pp. 447–451).

Of all the divisions of America, Canada may be said to be the chief for the growth of valuable timber. When first discovered, it was almost an unbroken forest of trees. Since then, however, vast quantities of Pine timber of very fine quality have been exported from it, as well as of Oak, Maple, and other kinds. The timber is felled and prepared for removal during the winter, and is floated down the rivers to Quebec in summer, where it is shipped to nearly all parts of the world.

The extent of land occupied by these forests is enormous. If only they were properly dealt with, they could hardly fail to be a source of great revenue to the country, and to continue to produce annually, for an unlimited time, as much timber as they do now. But, unfortunately, indiscriminate felling has long been going on everywhere. In time this must lead to the entire clearance of the best timber, and must ultimately render these great forests of comparatively little value.

The chief kinds of trees indigenous to this part of the American

continent, and which make up the existing forests, are *Pinus Strobus*, *P. resinosa*, *Abies nigra*, *A. alba*, *A. Canadensis*, *Thuja occidentalis*, *Larix Americana*, *Ulmus Americana*, with many species of Oak, Maple, and Ash, together with several species of Birch, Poplar, and Willow; while there are also the Lime, Beech, Butternut, Hickory, Hornbeam, Alder, &c., &c. Some of these, and the *Pinus Strobus* in particular, attain large dimensions of timber.

In the far west of British North America—that is, in British Columbia—there are large forests of *Pinus Strobus* and other coniferæ, including the Douglas Fir, *Pseudotsuga Douglasii*. There, in many instances, the latter tree attains a height of fully 300 ft., with a diameter at the base of the stem of about 10 ft.

Forestry in Canada.—As yet forestry is but little understood in Canada, and has been put into practice only on a small scale here and there. Here, however, as well as in the United States, the Provincial Governments, and especially the Government of Ontario, are, there is reason to believe, preparing themselves to enter on and carry out a scheme of forest economy worthy of the country and of the people. This is, in respect to Ontario, to conserve and improve large portions of the existing forests in various parts of the province; to establish suitable nurseries for the rearing of young trees; and to make new plantations on all the cleared and unoccupied parts of the reserves.

No country in the world would be more benefited by extensive planting than Canada, as its long and cold winters would be very much ameliorated by them, while the great heat of its summers would be moderated from the same cause; and thus the agricultural interests of the country would become vastly improved, whilst every other branch of industry would be strengthened in proportion.

Plantations do exist here and there in Canada; but they are of small extent generally, and are much neglected in the way of thinning. In short, no definite system of forestry has as yet been put into practice in Canada, though there is every prospect of this branch of rural economy being taken up and systematically attended to ere long.

Planting.—In Canada planting is performed in most cases in ways very similar to those described with respect to planting in the States of the Union. In the province of Manitoba, however, young trees are sometimes planted in lines ploughed each 3 ft. in breadth, and from 6 to 8 ft. apart, so as to leave strips of unploughed land 3 and 4 ft. in breadth between the lines of trees planted. These unploughed strips are meant to prevent drought from injuring the roots of the young plants, and to protect them by the herbage that grows up there. Planting in the older parts of Canada is generally performed by making holes for the trees, and here also the most of the young trees

used are obtained from the plants that grow naturally in the districts. These generally succeed well when properly chosen, as there is the great advantage of the plants being planted as soon as they are removed, and of their undergoing little or no disturbance from exposure to the air.

2. **The United States.**—No country in the world can well be better adapted to the healthy growth of a great number of species of trees than the great region possessed by the people of the North American States.

Looking at the country in its length and breadth, it embraces every variety of soil and climate that an arboriculturist could wish. In addition to the wealth of indigenous timber, trees from nearly all parts of the world may there be found growing as luxuriantly as in their native habitats.

In the southern parts of this country, and on the Pacific side, the trees of India, Australia, and Africa thrive remarkably well. The *Eucalypti* of Australia generally make annual growths of from 4 to 6 ft., while species of trees from Africa and India throw up shoots of good length.

The central parts of the country, having somewhat severe winters, are not adapted to grow so many foreign species as are found to succeed in the southern and western tracts. Still there, in addition to the native trees, many of which grow to great size, all the trees of Europe thrive luxuriantly; and they generally attain greater dimensions of timber than in their own homes.

In the Northern and Eastern States, from the winter climate being severe, only the hardier species of foreign trees succeed well; hence this class of exotics has chiefly been introduced from Northern Europe and Asia. Here, however, the native trees are in all respects excellent, as they produce timber of large dimensions and of the best quality.

In the Northern and Eastern States very few of the trees indigenous to the Southern and Western States succeed well, owing to the great differences existing in the climates of these respective tracts.

From what has been stated above it may be inferred that, as the United States embrace so many degrees of latitude and exhibit such extremes relative to elevation, a great diversity of soil and climate must exist. On the whole, it may be said that its soil and its climate are unsurpassed for the growth of a great variety of trees; and the very diversity of climate is specially favourable to the cultivation of a large variety of timber crops.

The American forests have been the greatest and most productive in the world. Nature, in forming this vast continent, seems to have

devoted her whole energies to the production on it of trees of the most useful and varied forms, and even to have produced some species which may well be termed the giants of creation. The great number of species of trees found in these forests is as wonderful as the extent of land they occupy and the size many of them attain. The various species are not, generally speaking, found growing in exclusive masses, but nearly as regularly intermixed as if they had been planted by the hand of man. In North America nothing can be imagined more perfect in variety of colouring than the mixture of the dark Pines with the lighter shades of the hardwoods. This is particularly the case in the autumn months, when the deciduous trees have their leaves changed from green to all the shades running between light yellow and dark crimson.

The extent of the American forests is still very great, notwithstanding that large portions of them have been cleared by man. We who live in Britain are accustomed to look on a plantation of 1000 acres as a large mass of wood; but when the mind is brought to contemplate the vastness of the American forests, it is almost lost in astonishment. The forests, made up of some of the largest and finest timber known, stretch in dense unbroken masses for many hundreds of miles in every direction.

The value of these forests is enormous, even taking them at a low valuation.

In the Northern and North-Eastern States the kinds of trees found growing are the same as those named in respect to British North America, together with fine specimens of the Tulip-tree and *Platanus occidentalis*, Sweet Chestnut, &c., &c.; while in the Southern States there is a large proportion of the trees of the North, together with Pines and many others suitable to the warmer climate there.

In the Western States there are many kinds of Pines and other trees not indigenous to the Eastern lands. In the State of California there are found growing some of the largest and most magnificent trees in the world, especially the mammoth-tree (*Sequoia gigantea*), which is now too well known to call for further remark. It may be also noted here, that from the State of California we have received a large assortment of the newer coniferæ now cultivated in Britain.

As a whole, the forests of the United States present many peculiar features of interest to the arboriculturist, for they have probably supplied Great Britain with a greater number of accessions to her arboretum than any other country in the world.

Some of the most prominent nurserymen in New York and Philadelphia appear, by their catalogues, to have most of the trees and shrubs of Europe in their grounds. The introduction of exotic trees into America began almost as early as the first settlement of the country;

and it has since steadily been continued, owing to the never-ending desire of the people to possess something new.

From the much-felt want of trees in some of the Western States where prairies exist, planting on a very extensive scale has been going on in many parts for some years past, and nurseries of large extent are quite common in the States. These send out annually a number of plants and trees which in this small country would be considered fabulous.

Planting in the United States.—In the Prairie States of the Union, farmers generally plant hedges and shelter-belts of Willow-trees in the following way. The cuttings are usually made from the branches of trees, and are from 3 to 6 ft. in length, pieces of from 2 to 3 in. in diameter being selected. When the cuttings are in readiness for planting, a trench of 15 in. in depth is made by the plough or spade, as the case may require, into which they are then placed in a regular line, and about 12 in. apart; whilst after that the soil is returned into the trench, and made firm about the cuttings. One row of such cuttings is considered sufficient for making a hedge fence; but if a shelter-belt be wanted, then three, four, or five lines of them are planted parallel to each other, and from 4 to 6 ft. apart, line for line, as the proprietor may consider necessary. Such hedges and belts grow up rapidly. In a few years they attain a height of 20 ft., and produce abundance of wood for fuel, as well as a considerable degree of shelter to the crops and shade to the live stock on the lands in their vicinity.

In many parts of the States crops of young trees are raised by sowing the seeds on the land they are to occupy permanently. In doing this the land is previously ploughed and harrowed, so as to secure its being in a good condition for the reception of the seeds. The different kinds of seeds are sown on this prepared land in lines separately,—for example, Ash in one line, Maple in the second, Elm in the third, Oak and Chestnut in the fourth and fifth, and so on, as the case may be. Previous to sowing the seeds the land is marked out into squares by the plough, as if Indian-corn were to be sown on it, and at the intersections of the furrows the seeds are sown, four to six at one spot. The distance apart may be 3, 4, 5, or 6 ft., according to the views of the farmer. The land thus sown with tree-seeds is kept clean, and sometimes agricultural crops are raised on it between the lines of trees for two or three years, or till the young trees have attained a fair size. When the plants have all come up, they are thinned to one plant at each spot, and blanks are filled up with surplus young plants taken out, as the state of the crop may require, in order to produce only a sufficient degree of density. In such cases the young trees grow so rapidly that at the end of six or seven years from the

time of sowing, if the plants stand 3 ft. apart, every alternate row is removed; at the end of ten years every alternate tree in each row left has to be removed; and at the end of twelve years from sowing, the stems of the young trees have generally attained about 6 to 8 in. in diameter near the ground.

Timber crops in the United States are not, however, always raised from seeds, but more frequently by means of planting. In this case the plough is for the most part used, and in either of the following two ways:—1st, The land having been previously ploughed and harrowed, furrows are drawn from side to side of the field, at the exact distance apart at which it is intended to plant the young trees, say at 6 ft. apart. The field being marked off in this way by parallel furrows, others are next run across them at the same distance apart, so as to mark off the whole of the field into squares of 6 ft. on the side; and at the intersections of these furrows the plants are inserted with the spade. 2nd, The spade is not always used for planting. When it is considered desirable to have the work speedily and cheaply performed, the plough only is used, in such way that furrows are drawn in the first place from side to side of the field, and at 6 ft. apart, as in the former case; but instead of crossing these by other furrows at the same distance apart, the men plough the whole of the land across, while a lad puts in the plants at the desired distance apart as the work of ploughing proceeds, taking care to insert them on the lines of the first furrows made. In this way the roots of the young trees are covered by the plough, and the work of planting is thereby completed.

In planting young trees on old woodland in the United States, holes or pits are made for the reception of the young trees, in the same way as obtains in Great Britain. In such cases, however, a supply of young trees can generally be had from the seedlings that grow up naturally in the districts where operations are being conducted.

Condition of Forestry throughout North America.—In a comparatively young country like North America it is not to be expected that forests and plantations should be found in such a high state of cultivation as they are in the older States of Europe. In the former case the inhabitants have had to clear vast tracts of natural forest in order to make the land available for raising cereal crops for food; and therefore they have not till recently had the necessity forced upon them of devoting their attention to the rearing of tree-crops. But now they are finding their supplies of timber becoming totally insufficient for their demands, and endeavours are strenuously being made to conserve the areas still under forest. Even at the existing rate of felling, it seems probable that there may be something like a timber famine in America within the next quarter of a century.

For a considerable number of years past, however, large plantations have been made in most parts of North America, and more particularly in the Western States of the Union, where comparatively few trees have existed of natural growth, and where, therefore, the settlers are compelled to plant, in order both to rear a supply of wood for domestic purposes, and to shelter their agricultural crops from storms that were wont to prevail in those formerly treeless regions.

The forests of natural growth in North America, although still of vast extent, are being rapidly cleared for the settlement and wants of the inhabitants; so much so, that the respective Governments are now meditating an extensive conservation of them in order to secure the keeping up of a supply of useful timber till plantations shall have been reared of sufficient extent and age to ensure a supply being had after the timber of the existing natural forests may have become exhausted.

The existing forests of natural growth in North America are nearly all in a patchy and uncared-for condition, from the fact that the Legislatures have only recently paid any attention to them, and that previously—and indeed in most cases even still—the settlers cut down the best and most valuable of the trees wherever they had need of them, leaving only the inferior and least valuable portions as the existing crops. This may be said to be the condition of the natural crops wherever the settlers have had access to them. But the forests which lie beyond the reach of the settlers—and there is still a vast extent of such tracts—contain a large amount of fine timber; for all of them are in a state of nature, the hand of man not having as yet ever been raised in their destruction.

The older classes of the plantations of North America are, generally speaking, in a condition similar to many found in Europe—that is, a great part of them has been allowed to grow up without attention to systematic thinning, and in consequence of this neglect the trees are generally of a drawn-up character. Here trees of all kinds grow with a remarkable rapidity. In a few years from the time of planting they attain a considerable size, and become useful to the settlers for many purposes. The settlers do, of course, thin their plantations in their own way; inasmuch as when they want trees for any purpose, they fell them, and remove them from the crops, but only in so far as they are wanted at the time. No systematic course of thinning is applied, and therefore, as already hinted, the crops are for the most part crowded, though on other parts patchy and thin from the removal of trees which have been taken for use on the farms. The foregoing remarks in respect to plantations are applicable to all those found in most localities throughout the United States.

Forest science in the United States of America may be said to

be as yet only in a state of infancy, by far the greater part of the people there being consumers of wood, while only the few are planters of trees. Of late years, however, the Agricultural Departments of these States have paid great attention to the matter of forestry, and are at present devising a scheme for conserving existing woods and planting new forests; and therefore in due time we may reasonably expect that the work of planting new lands and replanting old woodlands will be undertaken on a scale consistent with the wealth and resources of such a great country. The most intelligent part of the people of the United States are now aware of the evils incurred from the indiscriminate clearings that have been made of the original forests everywhere, and of the immense advantages that result from judicious planting; and they now seem to have made up their minds to enter on a new era in respect to the improvement of the land and the climate by growing trees in a systematic way, wherever this may be found necessary, both for the advantage of the landholders individually, and for the welfare of the country generally.

Although forestry has been very much neglected in the past, still the author is aware from his own observations, while travelling in the country, that extensive plantations have been, and are being, made by private landholders in all parts of the country, and especially in the Western and Prairie States, where they are an absolute necessity in order to protect the crops and stock of the settlers from the storms prevailing there; for it is fully admitted by the inhabitants of those regions that they are vastly benefited by the presence of the plantations which have been made, although these are of small extent compared with what remains to be done.

The kinds of trees generally found growing in such plantations are Plane, Sycamore, Ash, Elm, Scots Pine, Weymouth, Austrian, and various other Pines, together with European Larch and Spruce, intermixed with Sugar Maple, Black Walnut, Hickory, Black Cherry, Chestnut, Oak of various species, Locust-trees, Poplar, Virginian Willow, Juniper, Common Arbor-vitæ, and many other species of coniferous and broad-leaved deciduous trees.

Of the species named, preference is generally given to the Sycamore, the Scots and Austrian Pines, and to the European Larch and Norway Spruce, as being the most rapid in growth, and maintaining a healthy condition on most soils and situations.

All that is wanted in order to have North America made a well-wooded country is for the Government—or the Legislatures of the respective States—to conserve extensive portions of their existing forests, together with a large extent of their waste lands adjoining each reserve. Within these the existing crops could be much improved, and new plantations formed upon the most approved system

of modern forest science. This would be an example to all private landholders in rearing plantations on their respective properties; and it would soon lead to a state of things quite the reverse of what now obtains with regard to forest management as at present understood and practised in these States. There are some extensive nurseries in the States, in which are reared all the different kinds of trees used in planting.

There can be no doubt that the Division of Forestry, ably presided over by Mr. B. E. Fernow, acting under the Department of Agriculture, has during the last few years being doing admirable work under conditions of no ordinary difficulty. Even for the sake of the timber market of Europe alone, its further success is greatly to be desired. This subject has, however, already been referred to in some detail in vol. i., chap. i. pp. 27, 28.

The north-eastern portion of the United States, when first discovered, was covered by dense forests similar to those now occupying British North America. This part is now, however, to a large extent cleared and under the plough, so that no forests of any very great extent are in existence there. In the Western States, however, there are still great forests luxuriating in a state of undisturbed nature. Large supplies of Pine and other timber are still obtainable from these forests, but chiefly for home use; comparatively little export trade in timber is carried on by the United States.

3. Mexico.—The forests of Mexico are also of large extent, but no reliable data are available to enable us to form a correct estimate of them. Here there are magnificent specimens of many of the so-called newer coniferæ to be found on the mountain districts, of which a large number have now been introduced into Britain—for example, *Pinus Devoniani*, *P. Russelliana*, *P. macrophylla*, *Abies religiosa*, *Cupressus thurifera*, &c., &c.

4. South America.—In the north of this portion of America there are the plains bearing only occasional groups of trees; in the middle or tropical parts of it there is the great basin of the Amazon, called the *Silvas*, this being exclusively occupied by forest-trees; while in the south there are the Pampas, those treeless plains which extend for more than 2000 miles, with an average breadth of some 500 miles.

It might, therefore, be inferred that a great part of South America is made up of plains destitute of trees, and that it does not contain so much woodland in proportion to its surface as North America does. In the basin of the Amazon, however, there are nearly 400,000 square miles of the country under a thick crop of wood, interpenetrated by innumerable creeping and trailing plants.

The character of the forests here is something very wonderful. Grand, gigantic specimens of trees of many different kinds mingle together. Large trees display the most brilliant colours in their flowers, and others have rich clusters of many-hued blossoms hanging from their branches.

In the warmer or tropical parts the chief kinds of trees are Palms in great variety, Breadfruit-tree, Wild Figs, Logwood, Mahogany, Brazilwood, Cassias, Bignonias, and Melastoms; while in the more temperate regions a large proportion of the trees consists of Araucaria, Pines, Spruces, and other coniferæ.

"Though without forests on the south-east, South America begins to be a timber-producing continent in the islands of the extreme south, where 'Cipre' (*Libocedrus tetragona*) is largely felled; whilst north of the Straits of Magellan *Fagus antarctica*, the 'Chilian Beech,' *F. Forsteri*, and *Drimys Winteri*, 'Winter's bark,' are abundant. In the inner valleys of the Chilian Cordilleras there are extensive virgin forests of large timber-trees; and the same is true of the upper part of the 'Sierra' region of Peru and the 'Montaña' region. *Podocarpus chilensis*, *Thuja chilensis*, and *Araucaria imbricata*, the well-known Chili Pine, may be mentioned as characteristic of the southern area—'Lambras' (*Alnus acuminata*), 'Sauco' (*Sambucus peruviana*), 'Queñuar' or 'Oliva silvestre' (*Buddleia incana*), 'Paccay' (*Inga*, sp.), from the sub-tropical Sierras round Lake Titicaca; and the *Cinchona*, *Erythroxylon*, *Coca*, and rubber-yielding species of *Hevea*, from the Montaña region of the Eastern Andes. The scraggy 'Algarrobo' (*Prosopis horrida*), and the Willow (*Salix Humboldtiana*) of the Peruvian valleys, cannot rank as timber-trees, nor is timber an article of export; but the Montaña region is practically continuous with the interior of Brazil.

"**Brazil.**—The Brazilian empire possesses virgin forests covering an area half the size of Europe; and no less than 300 kinds of useful timber were sent from them to the Paris Exhibition of 1873. Many of these are not yet well known to botanists; but there is in the Botanical Department of the British Museum a manuscript volume by the late John Miers, F.R.S., many years resident in the country, entitled '*A Catalogue of the Woods of Brazil, arranged Alphabetically after their Vernacular Names, their Localities, Dimensions, &c.* . . . in which many of them are botanically identified.' 'Mattas,' or heavy forests, cover the immense humid lowland of Northern Brazil, and occur in belts in the plains of the central and southern portions of the empire; whilst the deciduous woods of the mountain slopes are known as 'Catingas.' Language altogether fails to picture the luxuriance of the vegetation of Equatorial Brazil. Among the most valuable timbers of Brazil are—*Cæsalpinia echinata*, 'Brazil wood,' 'Braziletto wood,' or 'Ibiripatanga,' which is hard and heavy, and takes a polish, but is largely used as a red dye; *C. ferrea*, 'Iron-wood;' *Dalbergia nigra*, 'Jacaranda' or 'Rose-wood,' the best of the genus, together with *D. latifolia*; *Cedrela brasiliensis*, the 'Cedar' of South Brazil; *Araucaria brasiliensis*, the Pine of the Organ Mountains; *Mimusops alata*, the 'Cow-tree' or 'Massaranduba' of Para; *Physocalymma floribunda* (nat. order, *Lythraceæ*), the 'Tulip-wood;' *Lecythis Ollaria*, the Sapucaya-nut; *Bertholletia excelsa*, the Brazil-nut; *Ocotea major*, 'Puchury;' *Persea gratissima*, the 'Avocado' or 'Alligator pear;' *Avicennia*, the 'White Mangrove,' the bark of which is used in tanning; and the numerous palms, of which *Copernicia cerifera*, the 'Carnauba,' 'Wax Palm,' is the most valuable. But rich in timber, the

Brazilian forests are still richer in rubbers, gums, resins, dyes, and medicinal substances—*Siphonia elastica* and *Hancornia speciosa* being among the chief rubber trees; *Maclura tinctoria* yielding fustic, and *Bixa Orellana*, arnatto.

"**British Guiana.**—The forests of Demerara, which cover the greater part of the country, contain hundreds of species of timber-trees, suitable for almost every purpose, growing together in a mixed virgin forest. The kinds most used in the Colony are—for building, 'greenheart,' 'mora,' and 'wallaba;' and for furniture, 'crabwood.' These timbers are almost imperishable, resisting damp and vermin, and can be readily brought to market" (Boulger, *op. cit.*, pp. 422–425).

III. The Forests of Australasia.—1. Australia.—This great country, extending between the parallels of 12° and 40° S. latitude, embraces many conditions of soil and climate, from the rich loam of the level plains, where the heat is excessive in the summer season and where snow seldom falls, to the poorer soils of the hills and mountains, which are of various heights up to 6000 ft. above the level of the sea, where the climate is comparatively cool even in summer, and where snow lies on the higher parts.

The trees indigenous to Australia are of a peculiar character, and nearly all of them are evergreens, as the change of the seasons produces no apparent influence on the olive-coloured tint of the forests.

The native timber-trees consist chiefly of *Eucalypti*. Of this genus there are many species, some of them attaining heights of over 300 feet, with proportional diameters. Species of *Casuarina* and *Acacia* are also common.

In some parts of this great country there are large forests of the trees named, along with other genera of less importance; but, generally speaking, the native forests are not extensive, compared with the total area of the country.

Both soil and climate, however, are well adapted to the healthy growth of trees from all parts of the world. In proof of this, it may be remarked that already very many species have been introduced from India, Africa, America, and Europe, all of which are reported to be thriving satisfactorily.

On the hills here all the coniferous trees of California are found to grow well, as also those of Europe and Asia; while the deciduous species of these parts of the world thrive equally well.

The Governments of South Australia, New South Wales, and Victoria are devoting great attention to the rearing of trees of all sorts from foreign countries; and wherever these have been planted on suitable soils they are promising good results.

The forests of Australia, exclusive of those of the province of Queensland, extend in all to about 160,000,000 acres.

In general the trees of this part of the world do not possess

many points of utility to recommend them as good timber, although, at the same time, it must be admitted that several valuable trees are to be found here.

"Though there are vast tracts in the interior of Australia covered with 'scrub,' the area of timber-producing forest is comparatively small, and belongs mainly to the eastern colonies. The foliage is usually evergreen, being often phyllodinous and glaucous. *Eucalyptus* and *Acacia* compose four-fifths of the forests, other prevalent genera being *Callitris*, *Casuarina*, *Banksia*, *Melaleuca*, *Xanthorrhœa*, and *Exocarpus*. From their rapid growth, and the durability, strength, and toughness of their wood, the gum-trees (*Eucalypti*) are especially valuable. Conservation has now begun; but mine-props, and even firewood, are locally scarce.

"**Queensland.**—Wooden buildings, the almost exclusive use of wood as fuel, railway and telegraph needs, and wholesale clearing for agriculture, have much thinned the timber of Queensland; but the red Cedar (*Cedrela Toona*, Roxb.), and Moreton Bay, Kauri, and Cypress Pines (*Araucaria Cunninghamii*, Aiton, *Agathis robusta* and *Callitris robusta*, R. Brown) are considerable articles of export.

"**New South Wales.**—Estimated to contain, in 1875, 82,700,000 acres of indigenous timber, the forests of that Colony, the variety of whose vegetable productions earned for it, in 1788, the name of Botany Bay, are chiefly Myrtaceous—*Eucalyptus*, *Angophora*, *Tristania*, *Syncarpia*, and *Melaleuca* being their chief genera; whilst the species are mainly identical with those of Temperate Queensland. The local names are, however, distinct. 'Cedar' (*Cedrela australis*) and Pine (*Araucaria Cunninghamii*) are the only timbers exported, the markets being China and New Caledonia, and the area under the former tree is rapidly diminishing. The timber-land is, however, largely in the hands of Government. Other principal species are:—*Podocarpus spinulosus*, 'Colonial deal;' *Flindersia australis*, 'Flindosa,' 'Wyagerie,' 'Cugerie,' 'Beech,' or 'Ash;' *Eucalyptus siderophloia*, 'Iron-bark,' the strongest and most durable wood in the Colony; *E. botryoides*, 'Blue gum,' but not the species so called in Victoria and Tasmania; *E. hæmastoma*, 'Spotted gum;' *E. rostrata*, 'Flooded gum;' *E. hemiphloia*, 'White box;' *E. corymbosa*, 'Yellow box,' 'Bloodwood;' *E. obliqua*, 'Messmate' or 'Stringybark;' *E. amygdalina*, or *E. Sieberiana*, 'Mountain Ash;' *E. robusta*, 'Mahogany;' *E. pilularis*, 'Black butt;' *E. resinifera*, 'Red gum;' *Syncarpia laurifolia*, 'Turpentine-tree,' which is teredo-proof and almost uninflammable; *Acacia pendula* and *A. homalophylla*, the fragrant 'Myalls;' *A. melanoxylon*, 'Blackwood;' *Ceratopetalum apetalum*, 'Coachwood' or 'Lightwood;' and *Casuarina tenuissima*, 'Oak.' The Kew Collection contains a fine series of New South Wales woods, 110 being enumerated in the 'Official Guide,' mostly with local names, but including many undetermined species of *Eucalyptus*.

"**Victoria.**—Nearly half the area of the Colony of Victoria (40,000 out of 88,198 square miles) was estimated in 1878 as forest, most of which is in the hands of Government. The great bulk of the timber consists of *Eucalyptus*, the chief species of which cover more than half the forest area. The Acacias are second in importance. The 'Red gum' (*Eucalyptus rostrata*, Schlecht.), sp. gr. ·858 to ·923, is the most valuable hardwood in the Colony, being very durable. It is used for piles, bridge planks, railway sleepers, ships' knees, &c., besides yielding kino, paper-pulp, charcoal, pearl-ash, tar, &c. The 'Blue gum' (*E. globulus*, Labill.) is scarcer (sp. gr. ·698 to ·889), but is similarly used. Its colossal size adapts it for outside planking. The

'White gum' (*E. amygdalina*, Lab.)—also known as 'Mountain Ash,' 'Peppermint,' or 'Giant gum'—exceeds 400 ft. in height, but is less durable. The 'Messmate Stringy-bark' (*E. obliqua*, L'Hérit.), sp. gr. ·809 to ·990—by far the most abundant and most generally used timber in the Colony—is inferior, being liable to twist; and the 'Iron-bark' (*E. leucoxylon*, F. v. M. = *E. Sideroxylon*, A. Cunn.), sp. gr. 1·106 to 1·024, is considered the strongest wood in the Colony, but is much smaller in size. It is used for cogs, spokes, shafts, and axe-handles. There is a small series of Victorian timbers at Kew. . . .

"Through the instrumentality of Baron Ferdinand von Müller, to whom Australian botany is so deeply indebted, several valuable exotic species, such as the Douglas Fir, the Deodar, and the Wellingtonia, have been successfully introduced into Victoria.

"**South Australia.**—As in Victoria, so in South Australia, the *Eucalypti*, misleadingly termed 'gum-trees,' since their produce is not a gum, but a kino, form the staple of the timber supply. *Casuarina*, or 'Oak,' yields woods suitable for axe-handles, spokes, &c. *Acacia melanoxylon* is the most useful of some thirty species of that genus; and there is a native 'Pine' (*Callitris robusta*), the wood of which, however, is not durable. The forest area is not large.

"**West Australia.**—Comprising, as it is estimated to do, over a million square miles, the whole of West Australia may be said to be forest, but nearly all the heavy timber occurs in the central and south-western districts, south of latitude 31°. A large amount of timber is annually exported, especially 'Sandal-wood' (*Fusanus spicatus*) and the magnificent 'Jarrah' (*Eucalyptus marginata*). This last species predominates over an area estimated at 14,000 square miles, the 'White gum' (*E. viminalis*) covering 10,000, the 'Karri' and 'York' gums (*E. diversicolor* and *E. loxophleba*) jointly some 5000, the 'Red gum' (*E. robusta*) some 800, and the 'Tooart' or 'Tewart' (*E. goniocephalus*) some 500 square miles. Other species are:—

Acacia acuminata, Benth. 'Jam' or 'Raspberry scented acacia.'
Banksia.
Casuarina.
Eucalyptus calophylla, R. Br. 'Mahogany.'
E. colossea. 'Karri.'
E. redunca, Schau. 'Wandoo.'
E. rostrata, Cav. 'Red gum.'"

(Boulger, *op. cit.*, pp. 454–477.)

Forestry in Australia.—The forests of Australia, although of a somewhat patchy character, are notwithstanding extensive as a whole; as already stated, they consist chiefly of Eucalyptus and Acacia. These forests, and especially those of the provinces of Victoria and South Australia, are being rapidly improved by their Governments, under the able superintendence of officers appointed to carry out in each case a thorough and well-defined system of forest economy. Here the crops in the natural forests are being conserved to a large extent, and systematically thinned of the weaker portion of the trees constituting them, all in such a way as to secure the better development of the healthy and promising portion; while the unoccupied sections of the land embraced are being planted not only with the best kinds of native trees, but also with many species from foreign countries known to be suitable to the climate, and capable of forming good timber.

Perhaps there is no Government in the world at the present time which takes greater interest in the welfare of its forests and plantations than that of South Australia, for here 240,000 acres of the natural forests are being taken in hand for improvement in the way of thinning and planting, while all is being done in such a systematic way that a satisfactory result cannot fail to be brought about in due time.

The plantations of these provinces are as yet young, few of them being of so long standing as to require much attention to thinning; but there is every reason to believe that in due time, as the crops need tending in this respect, they will be dealt with in a proper and intelligent way.

Planting.—In Australia planting is generally performed by making pits or holes for the young trees, as this method is found to be more certain in its results than that of sowing the seeds on the spots intended for the trees. Sowing has, however, also been put into practice to some extent. But the extreme dryness of the climate is found to prevent the seeds from germinating to a large extent; hence this method has not proved so satisfactory as that of rearing the young plants in nurseries, and planting them out into the forest ground afterwards. The chief kinds of trees planted on these woodlands are:—*Eucalyptus rostrata, E. corynocalyx, E. globulus, E. Jarrah marginata, E. viminalis, Pinus insignis, P. halepensis, P. maritima, P. Canariensis, P. Jeffreyii, P. sylvestris, Quercus pedunculata, Fraxinus Americana, F. excelsior, Juglans regia, Casuarina, Castanea vesca, Picea Smithiana,* and several other Spruces, with Poplar, Maple, and many other species indigenous to Europe and America.

All the young trees planted are distributed over the land, each sort on a soil and site adapted to its natural requirements, so that the whole are generally found to prosper well, and the greater part to make rapid progress. And it may be mentioned here that in distributing the young trees on the land they are planted at distances varying from 6 to 8 ft. apart, according to soil, site, and natural habits of the subjects—that is, on poor soils and exposed sites they are planted at 6 ft. apart, and on rich soils and sheltered situations they are put in at about 8 ft. apart.

Nurseries have been established in several of the Government reserves, in which a supply of young trees is reared for the planting of the enclosures. In most cases, however, the Oaks, Chestnuts, and Walnuts are raised by sowing the seeds of these on their permanent growing-places in the enclosures.

The foregoing remarks are of course applicable to forestry as it is being carried out by the Governments of these Colonies. Planting by private landowners has, however, been carried out to a large extent since they have seen the success of the Government operations; hence

it may very reasonably be inferred that this wise movement on the part of the respective Governments is destined ere long to bring about a great change for the better in regard to the improvement of the countries, both climatically and agriculturally.

2. The Forests of New Zealand and Tasmania.—The surface of New Zealand is a series of mountains, hills, valleys, and plains. The mountains on the North Island rise to an elevation of 9000 feet; while on the South Island they rise to the great height of 13,000 feet. On the lower slopes of the mountains and on the hills there are dense forests of the native trees; but the valleys and plains are also, generally speaking, well wooded, with extensive grassy ranges between the wooded portions.

In a country having such a diversity of surface as New Zealand has, it might be expected that there would also be a great diversity of soil and climate. And this is the case. In the valleys and the plains the soil is of a very rich character, with a warm and genial climate; while on the hills and on the lower parts of the mountains the soil is very variable, with a comparatively cool climate. Throughout the middle zones of the higher mountains the soil is not generally rich; it is very favourable, however, to the growth both of coniferous and of deciduous trees.

In this country snow seldom lies at the level of the sea. All the year round it lies, however, on the summits of the mountain ranges; but when frost occurs on the plains and valleys it is very slight.

From what has been stated above, it is to be inferred that the soil and climate of New Zealand are well adapted to the healthy development of very many sorts of trees, natives of foreign countries; and this has been proved by actual experience.

Most of the timber-trees of Europe have been introduced into this country, and also many species from Australia, besides a few from America. All of them grow well, and thrive as healthily as in their native homes.

"**New Zealand.**—One of the richest portions of the globe as regards arboreous vegetation is the Colony of New Zealand. It enjoys a climate similar to that of the south of Europe; the vegetation is most luxuriant, and many tropical plants flourish, while conifers, characteristic of colder regions, also abound. In Britain the number of indigenous timber-trees is only 35 out of a flora of 1400 species; while New Zealand has 113 timber-trees in a flora of only 1000 species. The forest area of New Zealand was estimated at over twenty million acres in 1830, and only twelve million in 1874, clearing then proceeding at the rate of 4 per cent. per annum. The forests which are not still in the hands of the Maories are, however, mainly in those of Government; and conservation has now been inaugurated. By

far the most valuable tree in New Zealand is the 'Kauri' (*Dammara australis*, Lamb.), which is confined to North Island. It grows 120 or even 200 ft. high, with a diameter of 10 to 20 ft., is very strong and durable, though not teredo-proof, is sometimes richly mottled, and has long been used in our dockyards for masts and spars. It also yields the valuable Kauri gum. Species of Pine and Beech characterise South Island, and the latter predominates on Stewart Island" (Boulger, *op. cit.*, p. 478).

"**Tasmania.**—Nearly one-half of Tasmania (eight million acres) is timbered, and of this area one-eighth is perhaps in private hands, though the area is diminishing. The bulk of the timber exported consists of 'Stringy-bark' (*Eucalyptus obliqua*), sent in planks to Victoria, South Australia, and New Zealand; but the most valuable timber of the Colony is the 'Blue gum' (*E. globulus*), abundant in the south, and very hard and strong, though of rapid growth. Tasmanian woods having been fully represented at the International Exhibition of 1862, there is a fairly complete series at Kew" (Boulger, *op. cit.*, p. 477).

Forestry in New Zealand.—The Government of New Zealand offered a liberal bonus to all its landholders who would plant and maintain in good order a certain proportion of their estates; and there is no doubt that the Legislature of the Colony acted wisely in thus holding out encouragement to planting.

There are few countries in the world whose climate is better adapted to the growth of trees than that of New Zealand; consequently a great many of the settlers have formed somewhat extensive plantations, not only of the native sorts of trees, but also of many species indigenous to Europe, America, Africa, and Australia. All of these are said to grow well here and promise to become valuable to their proprietors. In regard to the plantations of this Colony, we are informed that they are, generally speaking, well managed in the way of thinning, and that they already produce, in many cases, considerable revenues to those who own them, besides being of vast advantage in producing shelter to stock and crops in their respective neighbourhoods,—thus showing that forestry, in this far-off part of the world, is carefully attended to, so far as matters yet go.

The Government of New Zealand are understood to be taking active steps to preserve the native forests from further destruction, whilst also planting on a large scale, as is likewise being done in the sister colonies of Australia.

Planting has already been undertaken to a considerable extent by the settlers on many parts of both islands of this country; and the trees used are partly of the most useful species of native timber, together with a large proportion of the European coniferous and deciduous sorts. From this it is quite evident that the soil and climate of these islands are well suited to the growth of many species of foreign trees, and that ere long the country will become well clothed with the most useful trees of Europe and other foreign lands, so as to obviate the necessity of using the native timber,

which is generally much inferior to that of trees introduced from foreign parts.

IV. The Forests of Asia.—Asia surpasses all the other great divisions of the earth both in the greatness of its mass and the grandeur of its features. Comparatively little is known as yet, however, with respect to its forests, especially of those situated far within the interior. Even the information we now possess as to those lying along its boundaries and its coast-line is often but vague and unreliable. We are aware, however, that forests of great grandeur and vast extent do exist over a great part of this quarter of the globe; but to give anything like a reliable estimate of their extent is at the present time impossible, except with regard to our Indian Empire, and to Japan and Java.

In the southern parts of Siberia, dense forests of very fine timber are said to exist, consisting principally of Larch, Siberian Pine (*Pinus Cembra*), Scots Pine, Poplar, Birch, Oak, Lime, Juniper, and Willows. It is stated that here the *Pinus Cembra* attains a great height, and yields timber of large dimensions.

The only part of Asia of which we have, at the present time, full and complete information with regard to its forests is India, where a sound system of forest administration has gradually been introduced by the Government during the past thirty years.

China and Japan seem to have forests of considerable extent and importance. From both of these countries many different kinds of trees have been introduced into Britain; and many more are likely to be introduced later on, as these lands become better opened up to our commerce.

Forests in Russian Turkestan.—According to details given in the *Geographical Journal* for February 1893, Russian Turkestan is so poor in forests, and the existing woodlands have suffered so much of late from reckless cutting, that attempts are now being made to replant, partly in the mountains and partly in the Steppes. It is estimated that of the total area of Turkestan (162,000,000 acres), the territory has but 945,000 acres of forest-land in the mountains, and nearly 16,000,000 acres of bush-land in the Steppes. As to the plantations of trees which are met with in all native towns and villages, they cannot even satisfy the wants of the steadily increasing population for building purposes. The Saxaul tree has been pitilessly exterminated all along the banks of the Syr Daria, and for a great distance around the centres of population; hence the natives say, "The Saxaul has fled into the depth of the Steppes." The forests in the mountains were also recklessly cut down till the year 1879. At the same time, the whole of the region is, from some physical change, generally undergoing desiccation. Both glaciers and rivers are decreasing, the lakes dry up, the extremes of temperature become more marked, and the moving sands are increasing in area. The recent attempts at planting forest-trees without irrigation,

which were made in the province of Samarcand in 1880, have proved quite successful,—as also the attempts made in the dry Steppe in the south of Samarcand, between the Shaar-sabiz Mountains and the Dargh Canal, where nearly 400 acres were planted. Since 1880 the system has been improved, the young trees being now planted on the slopes of the hills in terraces, which follow the contour lines.

With regard to the other parts of Asia—excepting India, which will be treated of separately—the following is Professor Boulger's summary of the best information on the subject:—

"**Siberia.**—The absence of Oak, as of Heaths, east of the Urals is characteristic, though *Larix sibirica*, Led., shows the close connection of this flora with that of Northern Europe. Pines extend to 70° north; and *Picea cephalonica* and Birch are characteristic of the mountains; and Willows, Alders, and Poplars, of the plains.

"**Northern China.**—The flora of the interior of China is but little known. *Pinus koraiensis* occurs in Corea, and *P. Bungeana* in Northern China. *Larix Kæmpferi* and *Cupressus funebris* are further representatives of the Gymnosperms. Oaks, among which are *Quercus mongolica* and *Q. dentata*, point to the connection of this flora with that of the Himalayas; and other interesting trees, introduced into England about a century ago, are *Magnolia Yulan* (or *M. conspicua*, Salisb.), *Kölreuteria paniculata*, and *Ailanthus glandulosa*. The 'Lily-tree,' as the name Yu-lan signifies, reaches 40 or 50 ft. in height, and is allied to other deciduous species in Japan and in the Himalayas. *Kölreuteria paniculata*, Laxm. (nat. order, *Sapindaceæ*), grows only to 20 or 40 ft. in height. *Ailanthus glandulosa*, Desf. (nat. order, *Simarubeæ*), reaching 50 or 60 ft., is known in German as 'Götterbaum;' in Italian as 'Albero di paradiso.' It has been extensively planted near Odessa, and is commonly grown for ornament in England, and for shade in the eastern United States. It is the food of the Asiatic silkworm, *Bombyx cynthia*. The recent discovery of a Tulip-tree (*Liriodendron*, nat. order, *Magnoliaceæ*) in the interior, connects the flora of North China with the Tertiary fossil floras of Europe, as well as with the existing flora of America.

"**Japan.**—Japan, except in some of the hilly districts, has a luxuriant vegetation. The chief forests consist of *Cryptomeria japonica*, the 'Japanese Cedar,' or 'Sugi,' introduced into England in 1843. It ranges chiefly from 500 to 1200 ft. above the sea, and attains a height of 60 to 100 ft., with a diameter of 4 or 5 ft. It, together with *Planera japonica*, 'Keyaki' (nat. order, *Ulmaceæ*), is used for common lacquer-ware. Among Pines there are *Pinus parviflora*, Sieb. and Zucc.; *P. densiflora*, Sieb. and Zucc.; and *P. Thunbergii*; *Sciadopitys verticillata*, the Umbrella Pine; *Picea polita*; *Pseudolarix Kæmpferi*, the Golden Larch; *Thuja* or *Thujopsis dolabrata*, Sieb. and Zucc., 'Hiba;' *Biota orientalis*, the arbor vitæ; *Tsuga Sieboldii* (=*Abies Tsuga*), 'Tsuganoki;' *Retinospora* or *Chamæcyparis obtusa*, the Sun-tree, 'Hinoki,' reaching 70 ft. to 100 ft. high, which is burnt for charcoal; and *Gingko biloba*, L. (=*Salisburia adiantifolia*), the Maidenhair-tree, 'Ishio,' being the chief other representatives of the *Coniferæ*. The Evergreen Oaks, such as *Quercus glabra* and *Q. serrata*, Thunb., and the Maples, including *Acer polymorphum* and *Negundo cissifolium*, are among the finest Japanese trees; the Mulberry, Walnut, Chestnut, and Plum *Prunus pseudo-cerasus*), 'Sakara,' are cultivated, as is also the persimmon

(*Diospyros Kaki;* nat. order, *Ebenaceæ*); and among other characteristic trees are the Lacquer-tree (*Rhus vernicifera*), and Vegetable Wax-tree (*R. succedanea;* nat. order, *Anacardiaceæ*), the Camphor (*Cinnamomum camphora*, Nees, = *Laurus*); *Broussonetia papyrifera*, the Paper Mulberry; *Magnolia hypoleuca*, 'Honoki,' used for charcoal; the 'Ailanto' (*Ailanthus glandulosa*, Desf.; nat. order, *Simarubeæ*); the 'Yen ju' (*Sophora japonica*, L.), the flower-buds of which afford a dye; and *Paulownia imperialis*, 'Kizi,' from the wood of which the best lacquered articles are made.

"**Asia Minor, Syria, and Persia.**—The flora of this area differs but little from that of Southern Europe. *Quercus pseudo-coccifera* is by far the most abundant tree in Syria: *Q. Ægilops*, whose acorn-cups are imported for dyeing under the name of valonia, *Q. Cerris*, and *Q. infectoria*, whence Turkey gall-nuts are obtained, are also Levantine species; and forests of Oak ('mazu') occur also in Persia, as does also the Beech ('nûs') and Elm ('azad'), the Walnut (*Juglans regia*, L.), which probably has here its original home, as has also the Myrtle (*Myrtus communis*), which yields an oil and a hard wood useful in turnery; Plane, Sycamore, Ash, Yew, Box, and Juniper. Maples, Hornbeams, and Hazels also occur in this region; and the Terebinth (*Pistacia Terebinthus;* nat. order, *Anacardiaceæ*), and the cultivated *Melia Azedarach*, L., the 'Bead-tree,' 'Indian Lilac,' or 'Pride of India,' are also characteristic features in the vegetation. The coniferæ are represented by the Caucasian *Picea orientalis* and *Abies Nordmanniana*, Link., the Levantine *A. cilicica* and *A. cephalonica*, Loud., by the Aleppo Pine (*Pinus halepensis*), and above all by the Cedar of Lebanon (*Cedrus Libani*, Loud.), which probably gives place to the Himalayan variety, *C. deodara*, Loud., in the eastern mountains. The cultivation of the Olive is one of the chief industries of Syria, and the manufacture of articles from its beautiful wood forms an important trade in Jerusalem. The 'Iron-wood' of Persia is a species of *Parrotia* (nat. order, *Hamamelideæ*).

"**The Desert Region of Arabia.**—The flora of this region is practically continuous with that of Northern and Eastern Africa, extending from the Cape Verde Islands into Abyssinia and round the Persian Gulf, through Biluchistan and part of Afghanistan to the Indus. Almost all the plants are glaucous, many spinose, leaves being little developed, whilst gums and resins and pungent aromas are the rule. Trees are rare: *Pistacia*, *Terebinthus*, *Celtis*, *Dodonæa*, *Populus*, and *Phœnix dactylifera*, L., the Date Palm, being the chief. *Balsamodendron Myrrha*, Ehrenb. (nat. order, *Burseraceæ*), yields myrrh; and *Acacia nilotica* is said to have been the ancient 'Shittim-wood;' but this name has been also referred to *Dalbergia Sissoo*, the 'Shisham' of India.

"**Afghanistan.**—At a height from 6000 to 10,000 ft. we have *Cedrus deodara*, Loud.; *Picea excelsa*, Link.; *Pinus longifolia*, Roxb.; *P. Pinaster*, Soland.; *P. Pinea*, L.; Larch, Yew, Hazel, and Walnut, which latter, with various Evergreen and Kermes Oaks, descend to lower heights, where they are mixed with Alder, Ash (apparently the 'sir-kasht,' or manna-yielding *Fraxinus Ornus*, L.), 'khinjak,' *Pistacia Khinjuk*, J. E. Stocks, which yields a gum mastic, and on the north *P. vera*, L., the Pistacio; whilst down to 3000 ft. we have the Olive and *Zizyphus*. This flora passes into that of the Western Himalayas.

"**Northern India.**—The trees which do not require the moist heat of equatorial regions, and can resist the drought from April to June, are *Leguminosæ*, such as *Butea*, *Bauhinia*, *Acacia*, and *Dalbergia;* *Bombax*, *Shorea*, *Nauclea*, and *Lagerstrœmia*. *Magnoliaceæ*, *Camelliaceæ*, Oaks, and Rhododendrons are distinctive of the Himalayas, *Cedrus deodara* being hardly indigenous east of the sources of the Ganges, whilst *Pinus longifolia* forms

much of the forest on the warm slopes. The Tea-shrub (*Thea assamica*), the *Aucuba*, *Abelia*, and *Skimmia* are typical of the westward extension of the Chino-Japanese type; and the absence of *Tilia* and *Fagus* is also characteristic. *Abies Brunoniana* and *Smithiana* and the Larch (unknown in the western part of the Himalayas) are found at 8000 ft. in Sikim, the Yew and *Abies Webbiana* at 10,000 ft., whilst *Pinus longifolia* descends to the tropical zone. In Kumaon we have a more tropical flora, including *Moringa*, *Bombax*, *Butea*, *Anogeissus*, *Erythrina*, *Acacia*, *Bauhinia*, *Nauclea*, and *Ulmus integrifolia*, and still *Pinus longifolia*. In Kashmir the Plane and Lombardy Poplar flourish, and the vegetation, which in the higher mountains hardly differs even in species from that of Afghanistan, Persia, and Siberia, has an eminently European aspect, as has also the flora of Western Thibet, in which, however, the Juniper and Poplar are the only trees besides cultivated fruit-trees. The Pines of the Himalayas do not yield durable timber; but the Deodar is much used, the 'sâl' (*Shorea robusta*, Gaertn.; nat. order, *Dipterocarpeæ*), the 'toon' (*Cedrela Toona*, Roxb.; nat. order, *Meliaceæ*), and 'sissoo,' 'shisham,' or 'rose-wood' (*Dalbergia Sissoo*, Roxb.; nat. order, *Leguminosæ*), belonging to the lower levels, *i.e.*, below 3000 ft., though the 'toon' reaches the altitude of 7000 ft. in Sikim. *Acacia arabica*, Willd., the 'babul,' represents the Arabian type of North-West India.

"**The Indian Monsoon Region.**—This region includes (1.) the Dekkan, or Western Peninsula; (3.) the Malay Peninsula, with the intervening (2.) Andaman Islands; (4.) Sumatra; (5.) Java; (6.) Borneo; (7.) the Moluccas; (8.) New Guinea; (9.) the Philippines, and, as we have already seen, to some extent South China; and (10.) Ceylon. *Dipterocarpaceæ*, or Wood-Oil trees, *Apocynaceæ*, *Ficus*, and other rubber-yielding trees, and pitcher-plants (*Nepenthes*) are characteristic. Teak (*Tectona grandis*, L.; nat. order, *Verbenaceæ*) flourishes in the heavy rainfall of Southern India, the Malay Peninsula, Java, and Sumatra, its northern limit being about 25° north; whilst the other chief trees of this area belong to the orders *Terebinthaceæ*, *Sapindaceæ*, *Meliaceæ*, *Clusiaceæ*, *Camelliaceæ*, *Leguminosæ*, *Sapotaceæ*, and *Lauraceæ*.

"West Indian mahogany, *Eucalyptus*, and *Cinchona* are now extensively planted in India.

"In 1875–76 India exported over 60,000 tons of teak, 14,000 tons of myrobalans, 9000 tons of catechu, 4000 tons of shell-lac, 700 tons of caoutchouc, and 500 tons of sandalwood.

"**Sumatra and Java.**—Not less than a fourth of Java is still covered with forest. In the first, or tropical zone—*i.e*, up to 2000 feet—*Magnoliaceæ* and *Anonaceæ* prevail, other lofty trees being *Mimusops acuminata*, *Spathodea gigantea*, and *Irina glabra*. In the second zone—*i.e.*, up to 4500 feet—the chief tree is the 'Rasamala' (*Liquidambar Altingia*; nat. order, *Balsamifluæ*), which yields 'liquid storax;' others being 'Puspa' (*Schima Noronhæ*; nat. order, *Camelliaceæ*), a fine heavy red timber; 'Ki sapi' (*Gordonia excelsa*; nat. order, *Camelliaceæ*); 'Gadok' (*Bischoffia javanica*, Bl.; nat. order, *Euphorbiaceæ*); 'Bayur' (*Pterospermum Blumeanum*; nat. order, *Sterculiaceæ*), and *Epicharis densiflora* (nat. order, *Meliaceæ*). Besides the sago-palm, other trees are *Pangium edule* (nat. order, *Pangiaceæ*), a hard wood, with edible nuts and a bark used to poison fish; 'Kayu Gabas' (*Alstonia scholaris*, R. Br.; nat. order, *Apocynaceæ*); *Dipterocarpus trinervis*; *Podocarpus cupressina*, which grows to 200 feet high in Java and Penang; *Dryobalanops Camphora*, the Sumatra camphor; *Cratoxylon Hornschuchii* (nat. order, *Hypericineæ*); and *Engelhardtia spicata* (nat. order, *Juglandaceæ*), used for cart-wheels. *Cassia florida*, Vahl., known as 'juar,' indigenous in

Sumatra; the Surian (*Cedrela febrifuga*, Bl.; nat. order, *Meliaceæ*); and *Eucalyptus Globulus* are being largely planted in Java.

"**Borneo.**—Borneo possesses very extensive forests, besides mangrove swamps, and some most valuable timbers have been sent home by the British North Borneo Company; but unfortunately they are not yet well known, botanically or commercially. Several lists have been printed at Sandakan. They include 'Mirabou,' *Afzelia palembanica;* 'Rassak,' *Vatica*, probably three species; 'Kayu Kapor,' *Dryobalanops Camphora;* 'Seriah,' 'Serayah,' 'Selangan,' 'Majow,' or 'Borneo Cedar,' probably a *Hopea* (*Dipterocarpaceæ*), or several species; besides valuable woods, known as 'Billian,' ant and teredo-proof; 'Ballow;' 'Compass,' allied to 'Mirabou;' 'Greeting,' and 'Penago,' or 'Panagah,' known as 'Borneo mahogany.' 'Billian' is also known as 'Borneo iron-wood.' *Casuarina equisetifolia*, 'Chow' or 'Menkabang Penang,' used for masts and building; a species of *Calophyllum*, known as 'mast;' sandal-wood, and a species of ebony also occur; and sago and sappan-wood are among the products of the island" (Boulger, *op. cit.*, pp. 395–413).

V. The Forests of India.—The whole of British India, south of the Himalaya mountains, is unrivalled for its trees and other plants, many of the trees attaining vast dimensions, and producing timber of the best quality. Among these may be mentioned the Teak, the Sal, and the Cedar of India, and the Padauk and Pyingado or "Iron-wood" of Burma.

There can be no doubt that when the anticipated timber famine does take place in Europe and America (see vol. i. chap. i. p. 27), the enormous supplies of splendid timber which can be continuously yielded by the forests of Burma will prove of immense financial value to the Government of India, and of vast utility to the inhabitants of western countries. It is therefore sad to see the Government of India proving so apathetic with regard to the introduction of the finer and more durable species into the European market. Timber is like other articles of commerce, it requires to be well introduced to notice. But, just as good wine requires no "bush," so do the finer Indian woods only require to be known to rise at once into good demand for home utilisation.

The mountainous regions of Northern India have a temperate climate. In the central and southern regions the heat is so very great that palms and other tropical trees grow in abundance. As is to be expected in such a vast region, the soil varies from the richest found on the globe to the poorest on which vegetation can maintain itself.

Every one knows that the soil and climate of India are, generally speaking, highly suitable to the growth of trees from all parts of the world—its native trees of all sorts attesting this. Here there are all conditions of climate as well as of soil to be found on the earth, from the tropical to the arctic, thus securing suitable sites for the

healthy development of trees from all countries, whether tropical, temperate, or alpine.

Large portions of the still existing forests of India are being conserved by the Government, and systematically attended to by a qualified staff of foresters. And not only are the existing crops of the remaining woods being improved, but large extents are also being planted with trees both native and foreign; hence in due time it may be expected that India will become richly productive of the most useful of the timber-trees of Asia, Africa, America, Australia, and Europe.

Forest Conservancy in India.[1]—Forestry in India is a comparatively modern institution. In former times, no doubt, considerable areas were scrupulously protected in many parts of the country; but wherever this was the case, the forests were kept as game-preserves for the pleasure of princes and great nobles. The idea of conserving forests in order to maintain an uninterrupted supply of forest-produce, useful and even necessary for the people,—the idea of maintaining a proportion of the country under forests on account of the indirect benefits conferred on the empire at large by the very existence of forests—was never thought of by former Governments. Even during the earlier times of British sway, the economic value of forests was not recognised, and they were considered more in the light of impediments than otherwise to the increase of cultivation, and consequently to the general prosperity of the empire. This period, however, has passed away; and the necessity for the maintenance and conservative treatment of forests, as a mainstay of agriculture, is now almost universally recognised, while forest conservancy is regarded as a duty of the State.

India is not, like Europe, a forest-growing country throughout; its position in a tropical and subtropical climate prevents this, and areas which, with a lesser evaporation, such as takes place in temperate and cold zones, would be clad with dense forest growth, are here arid, and may even be desert. Thanks, however, to the barrier which, in the form of the Himalayas, separates the north of India from the rest of the Asian continent, and in consequence of the pronounced peninsular formation of the empire, the greater part of the country is suitable for the growth of natural forests. India is a country of extremes, and contains, on the one hand, evergreen forests of a luxuriance and density such as the imagination can hardly picture, and, on the other hand, deserts. The distribution and character of the Indian forests is due, in the first instance, to the more or less plentiful supply of rain, and next, to elevation and the influence of the tides. The distribution of the rains in India within distinct periods of time is as marked and accentuated as anywhere in the tropics, and, thanks again to the formation of the country, the monsoons extend far north of the Tropic of Cancer. There are two monsoons, the more important being the summer or south-west. Within the direct influence of the full force of the monsoon rains, the country is covered with evergreen forests. Where the rainfall gets less copious, these change into deciduous forests, gradually blending, with still decreasing rainfall, into dry forests, and ending in unreproductive deserts.

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[1] Extract from the Handbook of Exhibits of the Indian Forest Department at the Chicago Exhibition, 1893.

The evergreen forests created by the influence of the south-west monsoon occupy the west coast of the peninsula, up to the ridge of the mountain chain separating the moisture-yielding sea from the rest of the continent. In the same way they are spread over the coast districts of Burma and Chittagong, and along the foot and on the lower slopes of the eastern Himalayas. The evergreen forests due to the winter or north-east monsoon occupy the Carnatic.

The deciduous forests, which occupy the larger part of the peninsula and Burma, and a considerable proportion of the Andamans, are of the greatest importance for the forester, the consumer, and the State. They contain the well-known and most valuable species of timber, such as Teak (*Tectona grandis*), Sâl (*Shorea robusta*), Pyingado or "Iron-wood" (*Xylia dolabriformis*), Sandalwood, Red Sanders, and many others; also the Padauk (*Pterocarpus indicus*), which is found in considerable quantities and of large dimensions in the Andaman Islands. Pyingado and Padauk have, of all Indian timbers except Teak, probably the most promising immediate future.[1] Padauk yields the best wood for ordnance purposes and carriage-building, and is sure to rival mahogany for cabinet-work. The timber is stronger than Teak in every direction, lasts longer, is much handsomer, does not warp in seasoning, and only weighs 15 to 20 lbs. more per cubic foot.

The dry forests are situated in Rajputana and the Punjab, and spread over a large extent of Native States. Towards the north and north-west they become richer and gradually blend into deciduous or alpine forests, whereas they get drier and drier towards the west and south-west, and disappear into the deserts on both sides of the Lower Indus, where the courses of perennial rivers alone are fringed by a belt of arbori-vegetation.

Alpine forests are found within the Indian Empire along the whole of the Himalaya mountain chain from Assam to Hazara, in the mountains of South Afghanistan and Baluchistan, and on the higher mountain ranges in Burma.

The tidal forests are situated along the greater part of the coast of India and in the deltas of its rivers.

The foregoing are, shortly summarised, the physical capabilities of India as a forest-growing country. There can be little doubt that in pre-Vedic times the greater part of the Empire was covered with dense forests, which were gradually opened out by Kshatriya settlers along fertile valleys and main streams. At that time, and long after, the country was probably more fruitful and the climate less fierce than now, at least if any trust can be placed in the descriptions of Fa-Hian, the great Chinese traveller, who visited India in the fourth century, and who described the climate as neither hot nor cold. The destruction of the forests on a larger scale was left to the invaders from the north—nomadic tribes who had been accustomed to roam from pasture to pasture, and who fired alike hills and plains, and destroyed the forests wherever they went. The sway of these invaders extended over upwards of 750 years; and when, after the battle of Plassey, the foundation of the present Indian Empire was laid, and province after province was conquered, the forest areas had already, over considerable portions of the country, been reduced below the minimum necessary for its well-being, though other portions of the vast Empire were still covered with almost virgin forest.

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[1] The editor does not agree with this. If once it can become known in the shape of wood-paving, the Pyingado, or "Iron-wood," (*Xylia dolabriformis*) will ultimately command as large a market as Teak and Padauk combined. It is one of the best, and, at the same time, one of the most abundant woods of Lower Burma. Again, the Padauk of the Toungoo district of Lower Burma is heavier, and therefore more durable, than that obtainable from the Andamans.

Conservancy.—British rule, instead of putting an immediate stop to further devastation, gave in the beginning a new impetus to destruction. As already stated, the watchword of the day was to increase the area of cultivation, at the cost of the still existing forests, and this policy was carried on for years without any inquiry into the merits of each case. Naturally, incalculable harm was done by such inconsiderate destruction of forests, especially in the more populated districts, where the demand for new land was greatest, and where the forests were often already of less extent than the state of the country demanded. Large areas, though not immediately destroyed, were alienated by settlements and grants, and were thereby withdrawn from further active interference on the part of Government. Security to life and property enabled the peasants and herdsmen to graze their cattle far from their homes and unprotected, and at the same time cattle increased in value. Herds naturally multiplied, and additional grazing areas being required, were cleared by fire, thereby opening the way to future famines and distress. Railways soon spread over the country, and forest growth disappeared with an incredible rapidity within the reach of their influence, partly on account of the direct demands made on them for construction works—demands which were frequently supplied in a wasteful and reckless manner—partly on account of the increased impetus given to cultivation.

It was only when failures to meet local demands for public works were brought to notice, that the value of the forests was gradually recognised. At first, attempts were made to meet such local failures by local measures; but the insufficiency of this proceeding was rapidly brought to light, and it came to be understood that a question of such general magnitude and importance could only be efficiently grappled with by a special organisation. It was thus that the Forest Department came into existence.

As a matter of course, it rested with the Government to show the lead, and the first step in the new direction was naturally to ascertain the extent of the forest property still remaining in the possession of the State, and in what measure such property was burdened by rights in favour of the peasantry. The Oriental Governments, from which the British Government inherited its forest property, never recognised the accrual of any prescriptive right; but, on the other hand, anybody was accustomed, without let or hindrance, to get what he wanted from the forest, to graze his cattle where he liked, and to clear jungle-growth for cultivation wherever he listed. This state of things, it is self-evident, did not permit of systematic forest management, and it became clear that a Forest Law and a Forest Settlement were urgently required. It was necessary that the Forest Settlement should define (*a*) the forests in which the ownership of the State was still absolute; (*b*) forests which were the property of the State, but which were burdened with legal rights, prescriptive or granted; and (*c*) forests, the property of individuals or communities in which the State had rights over all or certain kinds of growing trees. After several local Rules and Acts had been introduced, and had been in force for a longer or shorter time, the first Indian Forest Act was passed in 1865. This was, however, found wanting in many important respects, and was replaced by the Act of 1878. Even in this new Act, however, faults were at once recognised, and separate Acts were passed for Burma and Madras in 1881 and 1882 respectively. All three Acts provide for the formation of Government reserves and the settlement of rights within them; also for the constitution of village forests; and they contain forest police rules necessary for the protection of Government forests and forest-produce. The Indian Forest Act contains in addition provisions for the creation of protected forests. All three Acts

provide for the control of Government over forests not belonging to the State, if such control appears necessary for the public weal, or if the treatment which such forests have received from their owners injuriously affects the public welfare or safety. More recently, special Forest Laws for the newly-annexed province of Upper Burma and for Assam and Baluchistan have been passed by the Indian Legislature, and these contain several distinct improvements on the older Acts.

In the Central Provinces and Bengal, forest reservation had made rapid progress under the wise guidance of Sir Richard Temple, and large areas could at once be declared State Forests under the Act of 1878. The rapid strides which forest reservation has made in Bombay are due to the wisdom and foresight of the same eminent statesman; other provinces are following the same line with more or less vigour, as may be gathered from the following table for 1891–92:—

Provinces.	Forest Area in Square Miles.				Proportion of Forests to whole Area of Province.	Remarks.
	Reserved.	Protected.	Unclassed.	Total.		
					Per cent.	
Bengal	5,211	2,181	4,534	11,926	8	(a) Includes 78 square mls. of *leased* forests. (b) Includes 343 sq. mls. of *leased* forests. (c) Includes 461 sq. miles of *taungya* areas. (d) Includes 113 sq. miles of *taungya* areas. (e) Exclusive of the area of india-rubber forests, of which it is not possible at present to form an estimate even. (f) Includes 37 sq. mls. of *leased* forests. (g) Includes 154 sq. mls. of *leased* forests.
N. W. P. and Oudh	(a) 3,769	93	54	3,916	4	
Punjab	(b) 1,715	481	3,874	6,070	6	
Central Provinces	19,680	...	393	20,073	23	
Burma (Lower)	(c) 5,615	...	...	5,615	7	
Burma (Upper)	(d) 1,059	(e) 16,461	...	17,520	22	
Assam	3,612	912	5,435	9,959	22	
Coorg	113	743	...	856	54	
Ajmere	139	...	...	139	5	
Baluchistan	82	...	...	82	...	
Andamans	...	...	1,957	1,957	98	
Berar	2,231	...	2,175	4,436	25	
Total Bengal Presidency	43,256	20,871	18,422	82,549	12	
Madras Presidency	(f) 7,175	(g) 9,404	1,304	71,883	21	
Bombay Presidency[1]	10,170	4,319	...	14,489	11	
Grand total	60,601	34,594	19,723	114,921	13	

[The following remarks concerning the practical effects of these areas are taken from the editor's pamphlet on the *Climatic and National-Economic Influence of Forests*, published by the Government of India, 1893, p. 21:—

"These areas, aggregating about 13 per cent. of the total area, have been demarcated with a view to their being permanently retained under woodland for future national-economic, as well as in some cases for financial reasons. This of course leaves out of consideration many vast stretches of unreserved tree-forest and bamboo-jungle still clothing the hill-sides in rocky tracts with poor soil, as well as large tracts on the richer plains in thinly-populated provinces like Burma and Assam, that will ultimately fall under the plough for permanent cultivation. But the mere statement of such percentage gives no indication as to how far the existing forests suffice for the maintenance of a prudent national-economic balance between

[1] These figures are for 1890–91.

the maximum of agricultural production and the safeguarding of the supplies of soil-moisture requisite for any agricultural success whatever. Even in a densely-wooded province like Burma, the percentage of woodlands give no reliable indication of the above nature; for though certain districts have more than the absolutely necessary amount of woodland, neighbouring districts are liable to suffer from insufficient harvests, and even from famine, when the monsoon rains prove deficient in quantity; whilst the danger of damage from floods after heavy rainfall becomes enhanced. In order to obtain the full national-economic benefits that are derivable from woodlands, the areas reserved as forests should be scattered over the face of the country as equally as possible. Where the population is thin, and primeval forest is still to be found, measures with this end in view can easily be carried out without inflicting any apparent hardship on the existing community. Where danger from famine is apt to recur from time to time, it would at the same time seem to be worthy of consideration whether it would not be well to expropriate tracts of the poorer and higher land here and there, and to plant them up on a well-considered scheme, for the purpose of ameliorating the climatic conditions both for man and for beast in the future.

"That the ill effects of too rapid and too extensive clearance of the wooded areas are also directly noticeable with regard to the pastural capabilities of any tract and the health of the animals grazed over it, as well as prejudicial to the crop-producing capacity of the land itself, might easily be proved. Thus Mr. Frost, V.S., the adviser of the Local Government of Burma in such matters, expressly stated in his Annual Report for 1884 that in his opinion the prevalence of certain cattle diseases in the Prome and Thayetmyo districts was doubtless attributable to the too rapid and extensive clearance of forest, which deprived the cattle of shade and shelter, as well as of proper grazing, during the hot season before the south-west monsoon breaks."]

Departmental Organisation.—The organisation of the Forest Department was gradually developed at the same time under the energetic management of Sir Dietrich Brandis. The Department, of which the superior staff was reorganised in 1891, is divided into an Upper Controlling Staff (including Conservators, Deputy and Assistant Conservators), a Lower Controlling Staff (providing for Extra-Assistant and Extra-Deputy Conservators), a Protective Staff (composed of Rangers, Foresters, and Guards), and an Office Staff. The Upper Controlling Staff numbers at present 183 officers, of whom 63 per cent. have received a scientific training in forestry, and were appointed in England by Her Majesty's Secretary of State. Most of these officers were trained in France, some in Germany; but since 1885 the education of such officers has taken place at the Royal Indian Engineering College near Windsor. The forest range is the unit of the present organisation, and the men intended for such charges, as well as those intended for employment in Native States or by wealthy native landowners, are trained in the Imperial Forest School at Dehra Dun in the North-Western Provinces. Since the establishment of the school in 1878, 166 Rangers have been thus trained. The organisation of the Controlling Staff has been, as pointed out above, completed; that of the Executive Staff, which must ultimately form the mainstay of forest administration in India, is now under the consideration of Government, and considerable additions to the existing numbers of Rangers, Foresters, and Guards will probably be made in almost every province.

The protection of the forests in which, previously to the creation of the

Forest Department, no restrictions of any kind existed, was, as may be supposed, a matter of the greatest difficulty. Boundaries were defined where no boundaries previously existed, or at least boundaries which had never formed a restriction had, under the Forest Law, to be respected. Previously, anybody might go into the forest, cut down in a most valuable portion all young trees over any extent of forest he wished, kill the mature ones and make a bonfire of the whole, sow in the ashes, reap a crop, and similarly destroy another area next year. A man wanting covering leaves for cigarettes might cut down a tree without let or hindrance; a cattle owner requiring more extensive pastures might fire and re-fire the forest, till it became sufficiently open to yield a dense grass-crop; cattle and even goats might graze and browse in the midst of forest reproduction. All this had to be stopped.

Protection.—As regards general protection, the laws, being new, had to be worked leniently. This has been done, and the progress reported from time to time is satisfactory. Where forests suffer, especially under excessive grazing, they do so more from rights granted and privileges permitted during the time of settlement than from subsequent breaches of forest rules. The greatest benefits conferred lies in the stopping of the above-described method of cultivation, locally known as *kumri*, *jhum* or *taungya*, in the Government forests of almost all provinces. This step affords, in the Central Provinces alone, protection to at least 5000 square miles, which otherwise would have been rendered bare once in every fifteen to twenty years. In the protection of forests from fire there is still much, to be learned and done, and in almost every province it is necessary to depend more on fire-tracing and fire-watching than on the help given by legislation. The law, while sufficiently stringent for reserved, and even for protected forests, is quite inadequate to protect them from fires spreading into them from adjacent private forests and grazing lands, and from open forests belonging to the Government, though the Burma Government has recently shown that most valuable results may be attained by insisting that the conditions of the law in regard to prairie fires shall be respected outside the forest areas. In all these classes of areas, fires intentionally lighted still often occur, and spread wherever the wind may carry them. This, apart from the mere protection of the Government forests, is probably one of the most important questions connected with forestry, and consequently with agriculture in India. These annual fires are the main reason of the barren condition of most of the Indian hill ranges, and are closely connected with distress and famine. Many prejudices will have to be overcome in order to check this evil, and it will take the full power of Government to do so.

In the meantime practical steps have been taken to prevent the spread of external fires into the more valuable Government forests. During 1891–92, 24,000 square miles were thus protected from fire, at a total cost of Rs. 242,000, and the following table gives a *résumé* of the work done :—

Results of Fire-Protection in the Forest Circles Administered by the Forest Department.

Circles.	Total Number of Acres.			Total Cost.	Cost in Pies per Acre.	
	Attempted.	Failed.	Protected.		Attempted.	Protected.
				Rs.		
Madras Presidency .	2,941,676	170,433	2,771,243	45,318	2.9	3.1
Bombay Presidency [1]	6,620,160	1,233,289	5,386,880	16,571	0.5	0.6
Bengal . . .	1,264,115	256,420	1,007,695	12,492	1.9	2.4
N. W. P. and Oudh .	1,741,038	61,797	1,679,241	48,714	5.4	5.6
Punjab . . .	189,916	23,594	166,322	2,106	2.1	2.4
Central Provinces .	2,476,395	135,008	2,341,387	52,191	4.0	4.3
Upper Burma . .	682,320	553,770	128,550	805	0.2	1.2
Lower Burma . .	320,867	3,338	317,529	31,344	18.8	18.10
Assam . . .	730,556	88,556	642,000	19,483	5.1	5.8
Coorg . . .	130,715	16,274	114,441	5,290	7.8	8.9
Ajmere . . .	89,228	...	89,228	45	0.1	0.1
Berar . . .	727,943	7,753	720,199	7,780	2.0	8.1
Total . .	17,914,929	2,550,223	15,364,706	242,139	2.6	3.0

By fire-protection, the regulation of grazing, and the general protection of the forests, ample reproduction is ensured, as a rule, after a shorter or longer period, in the more valuable forests of India, though, in some of the drier regions, areas thoroughly desolated and with unfavourable soil will resist improvement for the time being.

Management.—Most Indian forests are of a mixed character, containing only one or a few valuable species which repay the cost of working. Moreover, all age-classes are generally represented on the same area, and this necessitates working by the *selection* system (Ger. *Plänterung* or *Fehmelbetrieb;* Fr. *Jardinage*). It is self-evident that these facts make the problem of forestry—to secure a continuous yield proportionate to the stock on the ground without causing the deterioration of the forests—extremely difficult. In previous times the work was carried on haphazard, or based sometimes only on an exceedingly rough valuation of the growing stock. As a rule, however, the demand and requirements for forest-produce were the only considerations by which the exploitation was governed, and no attention was paid to the potential capabilities of the forests. Of late, however, more pretentious working-plans have been made, and several provinces have organised a division or staff for this work only. The working-plans made in the provinces under the Government of India are scrutinised and audited by the Inspector-General of Forests before they are passed by the Local Governments. The working-plans take special notice of all measures necessary to encourage, and, what is infinitely more difficult in a mixed forest, to guide natural tree reproduction; and they prescribe any artificial means—such as girdling of inferior trees, dibbling in of seed, &c.—that are required to assist natural regeneration of the species or admixture desired. The forests controlled by the Department are, however, by far too extensive, and markets at high rate are not at present sufficiently general

[1] These figures are for 1890–91.

and secure to permit of the extensive use of the more elaborate methods of European sylviculture. In special connection with the preparation of working-plans, the Forest Survey Branch of the Imperial Survey Department has been formed.

The exploitation of timber, at least of the more valuable timber, from Government forests, is carried out partly through the direct agency of the Department and partly by contractors. Of minor forest-produce, the most important at present are grass, myrabolams or hirda fruit (*Terminalia Chebula*), bamboos, cutch or catechu, cardamoms, caoutchouc or india-rubber, and lac; but there are many others of less value.

The estimated yield in timber and fuel in cubic feet of all Government forests was as follows during 1891–92 :—

Circles.	Timber.	Fuel.	Total.
	Cubic ft.	Cubic ft.	Cubic ft.
Bengal	7,260,725	21,495,028	28,755,753
N. W. P. and Oudh	4,204,645	7,673,285	11,877,930
Punjab	2,381,030	28,968,083	31,349,113
Central Provinces	1,756,433	6,760,265	8,516,698
Burma (Upper)	7,352,485	1,506,598	8,859,083
Burma (Lower)	11,773,094	2,802,034	14,575,128
Assam	2,246,290	2,608,988	4,855,278
Coorg	398,844	196,000	594,844
Ajmere	7,300	191,098	198,400
Baluchistan	6,122	152,588	158,710
Andamans	415,874	1,150,636	1,566,510
Berar	621,454	1,558,341	2,179,795
Madras	3,086,937	13,987,173	17,074,110
Bombay	6,842,524	26,422,016	33,264,540
Total	48,363,759	115,472,133	168,825,892

The following table exhibits information in respect of the sea-borne exports of forest-produce from India to foreign countries in 1891–92 :—

Articles.	Quantity in Tons of 20 Cwts., in the case of Teak, Cubic Tons.	Valuation at Port of Shipment.	
		Total.	Per Ton.
	Tons.	Rs.	Rs.
Caoutchouc	467	11,72,370	2,510
Shell-lac	5,514	60,67,924	1,100
Lac-dye	2	2,500	1,250
Sandal, ebony, and other ornamental woods	(Information not available.)	8,41,938	...
Cutch and gambier	9,853	31,72,992	322
Myrabolams	39,540	39,36,902	100
Teak	48,190	47,48,517	99
Cardamoms	124	3,18,957	2,572
Total in 1891–92	...	2,02,62,100	...
" 1890–91	...	1,77,40,556	...
Increase in 1891–92	...	25,21,544	...

Arrangements have recently been made for the dissemination of information on these and other important Indian forest-products among the

commercial community and other persons in Europe interested in the trade. Monographs on the more important products appear from time to time in the pages of the *Indian Forester*, and are subsequently republished in the series of penny handbooks issued by the Imperial Institute in London.

Financial Results.—The financial results of Forest Administration in India have been as follows:—

Quinquennial Periods.	Revenue.	Expenditure.	Surplus.
	Rs.	Rs.	Rs.
1864–65 to 1868–69 (annual average) . .	37,38,189	23,81,732	13,56,457
1869–70 to 1873–74 ,, . .	56,25,693	39,89,632	16,36,061
1874–75 to 1878–79 ,, . .	66,55,913	45,76,372	20,79,541
1879–80 to 1883–84 ,, . .	87,84,514	56,07,652	31,76,862
1884–85 to 1888–89 ,, . .	1,16,68,148	74,26,956	42,41,192
1889–90	1,53,03,572	80,12,518	72,91,054
1890–91	1,49,67,135	80,63,125	69,04,010
1891–92	1,53,63,706	86,23,852	67,39,854

VI. The Forests of Africa.—Africa is a division of the earth of which we know very little, excepting those portions of it which lie along the seaboard; and therefore we are not prepared to speak with regard to the extent of its forests. From observations made by that famous traveller Dr Livingstone, in the account of his travels in South Africa, we were first made aware that vast forests do exist in some parts. He says that in some places near the Cape there are mountains which are clothed with evergreen succulent trees, on which neither fire nor drought has any effect, and that the seaboard gorges are clad with gigantic timber. In another part of his work he speaks of seeing grand specimens of the "Baobab," or Monkey-Bread-tree, and of the "Mopane" tree. One of the Baobab-trees he saw measured 85 ft. in circumference at 3 ft. from the ground. The Baobab-trees seem to be wonderful examples of vitality. When the natives strip them of their bark for domestic purposes, they do not die, as would be the case with most other trees, but live and throw out a new bark by a process of granulation. It is said that this stripping of the bark is done frequently, and that no external injury, not even a fire, can destroy the tree. Dr Livingstone says that in several cases he saw trees of this kind cut down, and that even after they were separated from the stump, they continued to grow in length.

In Middle Africa the Oil-palm, the Arachis or Earth-nut, Gum Acacias, Cotton-trees, and the Shea-butter-tree, grow in abundance; whilst in the north the Orange and the Olive are to be found, with the Date and other Palms.

From the geographical nature of Africa, comprehending as it

does both tropical and temperate climes, there must be many different species of trees indigenous to it, especially in the central parts, of which we know nothing at present. Up to the present time, the number of species introduced from Africa is comparatively few. But when the continent has been thoroughly explored and opened up to science, we may hope to have many additions to our arboreta from its forests.

VII. The Forests of South Africa.—South Africa has a soil and climate excellently adapted to the growth of trees from foreign countries; hence there are now many of the trees of Australia, especially the *Eucalyptus* and *Acacia*, growing as well as if they were in their native habitats.

The surface of the country is very varied, and consists of a series of plateaux, rising in successive terraces from south to north, but separated by mountain chains; a few of the summits of the mountains rise to heights varying up to 9000 feet. These circumstances give rise to a great variety of soil and climate, suitable to the healthy development of trees from many foreign countries.

Southern Africa is, generally speaking, not well wooded, although the soil is for the greater part well adapted to the growth of trees of every sort. Still, there are here and there native forests stretching over large tracts of country.

A considerable extent of land has now been planted; and the success of these crops is ample evidence of the suitability of the country for raising timber of valuable dimensions. The kinds planted are chiefly Oak, Poplar, Cluster Pine, and Stone Pine, with Ash, Elm, and Sycamore, all of which have made rapid progress. The Indian Cedar, the Mahogany, and Banyan trees thrive well also.

The general dryness of the climate of this part of Africa renders it highly necessary that planting should be undertaken largely. Were this done, the climate would in due time be much improved.

"Though belonging almost entirely to the equatorial and tropical zones, Africa is divided by its desert regions into well-marked botanical provinces. That of the north, Morocco, Algeria, and Tunis, belongs essentially to the Mediterranean region, *Cedrus atlantica* and *Abies numidica* on Mount Atlas recalling similar associations on the Himalayas, on Lebanon, and in Cyprus. The Sahara is the region of the date-palm; the Soudan, that of the oil and sago palms, the baobab, and the silk-cotton; and this jungle-region is again separated by the desert region of succulent *Euphorbia Aloë*, *Crassula*, and *Mesembryanthemum* from the region of Heaths and *Proteaceæ* in the south.

"**Morocco.**—Though olives, grapes, figs, almonds, dates, chestnuts, walnuts, mulberries, and cork are cultivated, the most interesting species in Morocco are the ''arâr' and the 'argan.' The ''arâr' (*Callitris quadri-*

valvis = *Thuja articulata*, Shaw) is known as the 'Atlas Cypress.' It grows 30 feet in height, and its sweet-scented wood was the much valued citron-wood of the Romans, probably the 'thyine-wood' of the Book of Revelation (xviii. 12), and the 'alerce' of the roof of the cathedral (originally a mosque) at Cordova. This tree yields 'Gum Sandarach,' formerly used as 'pounce.' The 'argan' (*Argania Sideroxylon;* nat. order, *Sapotaceæ*), though seldom exceeding 20 or 30 feet in height, has a girth of 25 feet, and yields a hard wood. Its fruit is eaten by cattle, and crushed for an oil used in cookery. The cork-oak is still abundant. [Cosson, 'Compendium Floræ Atlanticæ,' Paris, 1881.]

"**Algeria, &c.**—With nearly 5,000,000 acres of forest, about three-fifths under State control, Algeria is rich in timber. *Pinus halepensis* and *P. Pinaster*, with *Cedrus atlantica* and *Callitris quadrivalvis*, are the chief conifers. *Quercus Suber*, *Q. Ilex*, *Q. castaneæfolia* and *Q. ballota*, with Elm, Ash, Maple, and Olive, are the chief Angiospermous trees. Cork, olives, and olive-oil, and bark for tanning, are the chief products of the forests. Tunis, once well supplied with Aleppo Pine (*Pinus halepensis*), is now denuded of timber; and Egypt, rich in Date-palms, has no forests, though *Acacia*, *Tamarix*, *Tamarindus*, and *Zizyphus* reach a considerable size and form wood. The Sycamore fig (*Ficus sycomorus*), used for making mummy-cases, was originally Egyptian. Abyssinia, the native home of the Coffee, has forests on the temperate and humid mountains of the interior, which are, however, less known than the luxuriant vegetation of Central Africa.

"**Central and Western Africa.**—The timber-trees of this region are not yet fully ascertained. Stanley mentions *Bassia Parkii*, the 'Shea' butter (*Sapotaceæ*); *Oldfieldia africana*, 'African Teak,' a wood introduced into England in 1819, belonging either to the *Sapindaceæ* or *Euphorbiaceæ;* 'Kola nut' (*Sterculia acuminata*), known by various names, and much used instead of betel; 'Cashew-nut' (*Anacardium*, sp.), and gigantic tamarinds. And from the colonies of the West Coast, together with other undetermined woods, we import *Swietenia Senegalensis* or *Khaza*, 'African mahogany;' *Pterocarpus erinaceus*, 'African Rosewood,' which also yields a Kino; *Blighia sapida*, 'Akee' (*Sapindaceæ*); and *Carapa guineensis* (*Meliaceæ*), which also yields an oil from its seeds. It occurs also in British Guiana, and is known as 'crabwood,' and the oil as crab-oil. *Baphia nitida*, 'barwood' or 'camwood' (*Leguminosæ*), is used mainly as a red dye. 'Dattock,' *Detarium senegalense*, Gmelin (*Leguminosæ*), is a dense dark brown wood.

"**Natal.**—The timber-trees of Natal, mostly growing in somewhat inaccessible situations, have unfortunately not yet been completely determined. . . . *Eucalyptus* and *Casuarina* are a good deal planted for fuel, and the Colony cannot now export timber; but there are 165,000 acres of forest occupied by heavy timber, besides nearly 2,000,000 acres of mimosa or thorn jungle. The root and bark of *Elephantoriza Burchellii*, 'Intolwana,' and much black-wattle bark (*Acacia mollissima*), are used in tanning, the latter being a naturalised plant."

"**Cape Colony.**—The chief forests of the Colony are in the south and east. Between Cape Town and Port Elizabeth some 150 square miles of forest, known as Knysna, remain under Government control. East of Port Elizabeth are the forests of Alexandria, Bathurst, and East London, near the coast; and some 130 square miles of mountain forest are on the Perie and Amatola mountains north of King William's Town. In the mountains of Clanwilliam are the remains of mighty cedar forests, *Widdringtonia juniperoides* still occurring on the slopes of the Cederberg, above the winter range of snow. Table Mountain is flanked with woodlands, especially on the south or temperate side, composed of *Leucodendron argenteum*, the

'Silver-tree,' which is only indigenous in this district, and three naturalised European species—*Quercus pedunculata*, *Pinus Pinea*, and *P. Pinaster*. The Knysna forest exhibits a semi-tropical luxuriance, the stout yellow woods (*Podocarpus*), the lofty black ironwood (*Olea latifolia*), and the most valuable stinkwood (*Ocotea bullata*), rising out of a densely tangled undergrowth. The increase of stinkwood is the chief end aimed at here. In the Eastern Coast forests stinkwood is unknown, and sneezewood (*Pteroxylon utile*) no longer abundant; but 'Septu' (*Halleria elliptica*) and 'Cape Teak' or 'Kajatenhout' (*Atherstonea decussata*) abound in the Alexandria forest; and boxwood (*Buxus ?*), with two apparently valuable species known as 'Bogwood' or 'Umcobèza,' and 'Unzumbit' or 'Umtiza,' occur in those at East London. In the mountain forests sneezewood, which is now protected by Government, is the most important timber" (Boulger, *op. cit.*, pp. 416–419).

Forestry in South Africa.—There are extensive forests in South Africa, a considerable portion of which has been taken into the hands of the Government for conservation and improvement. The greater part of these forests is, however, in a neglected condition, comparatively little having as yet been done for their improvement in the way of thinning out the weaker trees for the better development of the more promising ones. The planting of the unoccupied portions of land embraced has also been but little attended to.

The forests of South Africa could, under a proper forest administration, be made a valuable source of income to the Government of that Colony. But at present they are much neglected. They should be put under an improved forest economy, whereby the inferior portions of the respective crops could be judiciously removed and profitably disposed of, in order to admit of the greater development of the better classes of trees, which should be allowed to stand in order to become of more value.

And not only should the existing forest crops be attended to as stated, but extensive planting should also be undertaken, in order to secure a supply of timber for the wants of the country after the produce of the existing forests shall have been all used up.

A considerable extent of plantations has been made in South Africa, and particularly on that part of the country stretching along the base of Table Mountain. But besides these, many farmers here have planted on their own land, both for a supply of timber and for shelter to the land and live-stock. Indeed, plantations are every year being made to some extent by the farmers of the country, so that in some parts it has now quite a clothed aspect. Nearly all of these plantations, however, are allowed to grow up in such a state that the crops are generally of a drawn-up character, and much in want of thinning; for nothing is done in this way, excepting the removal of a few trees from time to time, in order to supply the wants of the farmers for domestic purposes.

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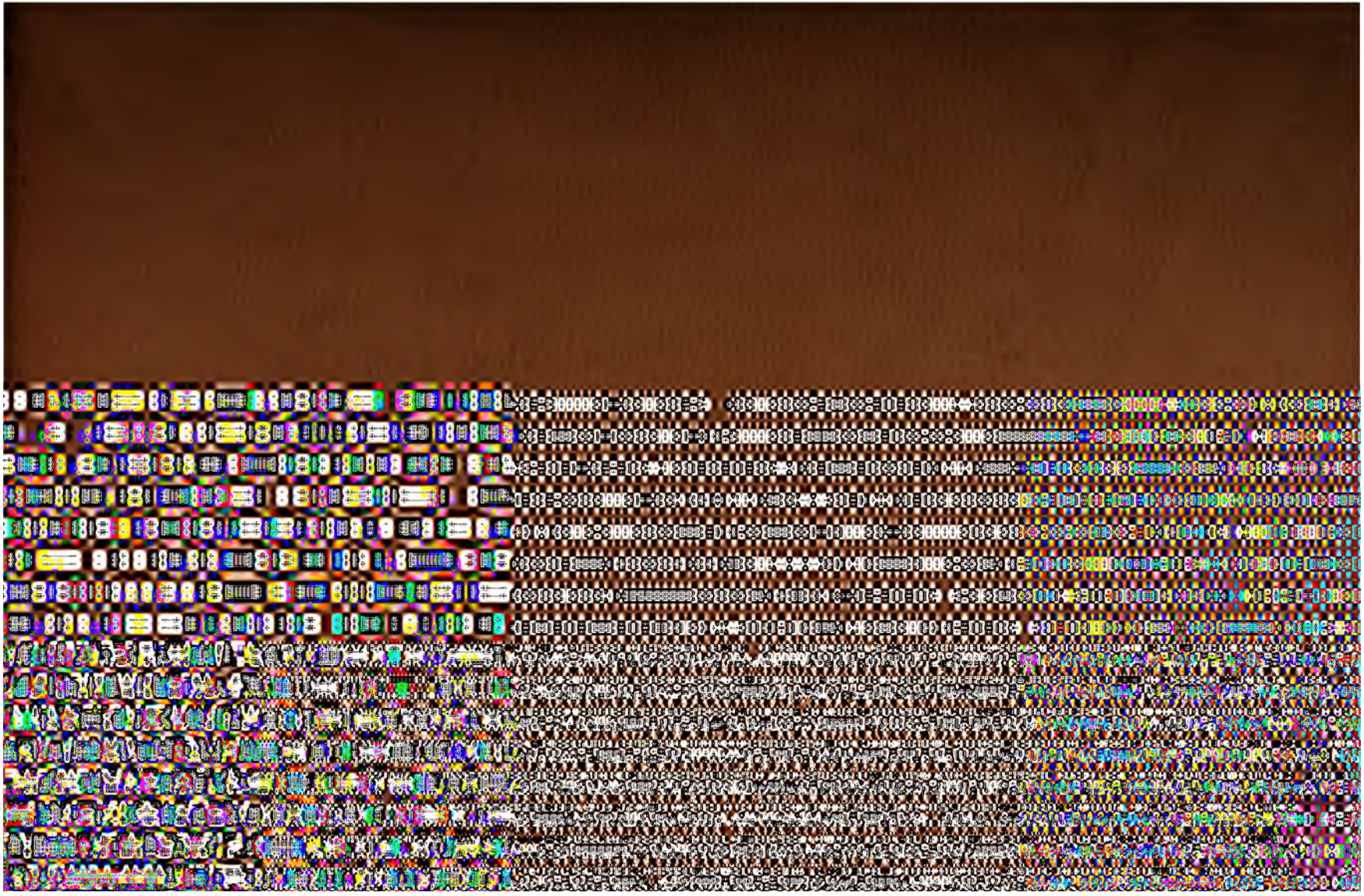

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